YOUR OFFICIAL RASPBERRY PI MAGAZINE

The MagPi

The official Raspberry Pi magazine

Issue 51 November 2016

raspberrypi.org/magpi

BUILD A REMOTE CONTROL ROBOT

Create your own Raspberry Pi-powered rover with our latest guide

MAKE AN UNDERWATER CAMERA

Get candid shots of your fishy friends with our help

TOTALLY WIZARD

Magical magnetic chess project straight out of Harry Potter

SEND YOUR CODE TO SPACE

New Europe-wide Astro Pi competition now open

SPOOKY HALLOWEEN PROJECTS

Build all our abs-ghoul-utely brilliant Pi hacks

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- THE FINAL PART OF OUR ARCADE CABINET GUIDE
- INSTALL WITH NOOBS & CONFIGURE YOUR PI
- HOW RASPBERRY PI IS HELPING BUILD CARS
- MONKMAKES ROBOTIC PUPPET KIT RATED

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WELCOME TO THE OFFICIAL MAGAZINE

We're still riding high on the success of last month's 50th issue, in which we counted down the best Raspberry Pi projects ever made. The response from our readers to the public-voted portion of our countdown – the all-important top 20 – was astounding, so please accept our heartfelt thanks for making it such a memorable community event!

We're back to business as usual this issue. Just the standard, everyday, run-of-the-mill articles you've come to expect from the magazine on a month-by-month basis. Standard stuff like shooting your code into space, building awesome robots, mastering essential computing expertise, and bootstrapping the impossible with nothing more than affordable technology, a free weekend, and the skills to succeed. Just the usual.

Enjoy the issue!

Russell Barnes
Managing Editor

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FREE PI ZERO
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PAGE 30
SUBSCRIBE & SAVE 25%
SEE PAGE 30 FOR DETAILS

THIS MONTH:

06 BLAST YOUR CODE INTO SPACE
Enter the new, improved Europe-wide Astro Pi competition

14 BUILD YOUR OWN ROBOT
Ladies and gentleman, we can build it. We have the technology

44 CONFIGURE YOUR RASPBERRY PI
Tweak your Pi's dials in another essential beginner's guide

48 MAKE AN UNDERWATER CAMERA
Take your Raspberry Pi for a swim with the fishes

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SEND YOUR CODE TO SPACE
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Contents

Issue 51 November 2016 raspberrypi.org/magpi

TUTORIALS

> RASPBERRY PI 101 – NOOBS **42**
Install one of many OSes with NOOBS

> RASPBERRY PI 101 – CONFIG **44**
Change the way your Raspberry Pi works

> HOW TO USE SCRATCH 2.0 **46**
Upgrade Raspbian with PIXEL to use Scratch 2.0

> UNDERWATER CAMERA **48**
Build a waterproof, Pi-powered camera

> INTRO TO C PART 5 **50**
How to use pointers in your code

> BUILD A WIFI DETECTOR **52**
Find out who's been at your house by using WiFi

> CREATE A STATUES GAME **54**
Play statues with a Raspberry Pi in the Pi Bakery

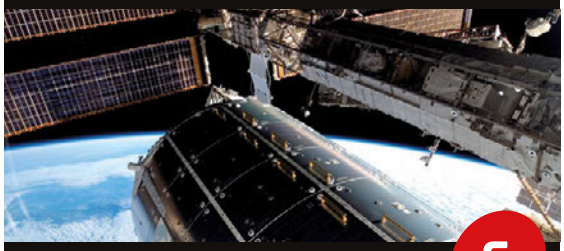
> ARCADE MACHINE PART 5 **58**
Finish building the RaspCade

> MAKE PONG WITH PI CAP **60**
How to make Capong, a physical version of Pong

> PIVR – PVR ON YOUR PI **64**
Upgrade your Pi media centre with a PVR

IN THE NEWS

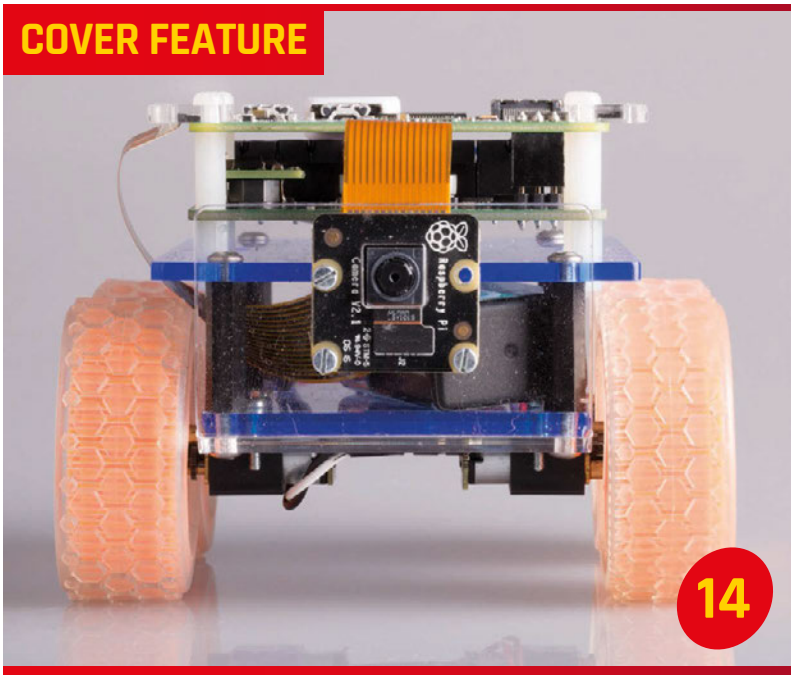
NEW ASTRO PI COMPETITION



Astro Pi is back with a Europe-wide challenge for kids to enter!

6

COVER FEATURE



14

BUILD A ROBOT

PI-MADE CARS

8

A car factory in Portugal has supercharged its production line with Raspberry Pis

PIIOT WINNERS

Element14's community challenge is over, with some amazing results

12

Contents

THE BIG FEATURE

68

EASY HALLOWEEN PROJECTS

Scare your friends with these quick Halloween projects you can do in time for the big day

WIN

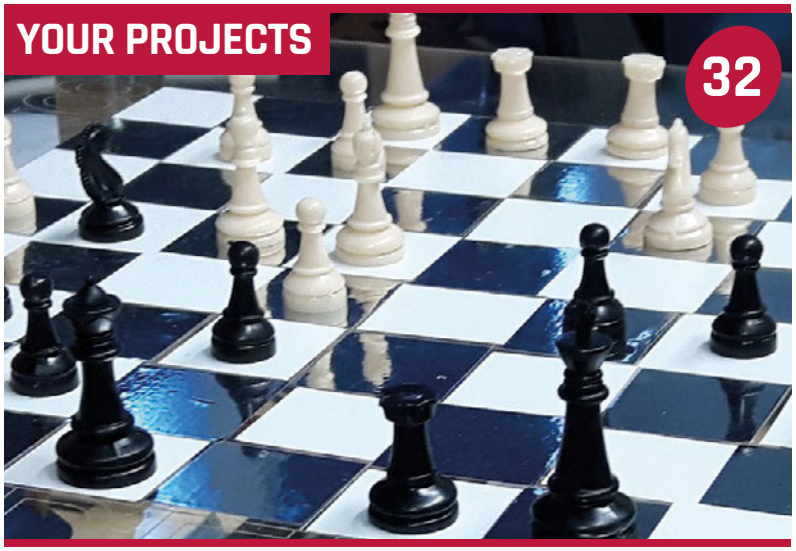
94

ONE OF TWO **PI-TOPCEEDS** OR A **PI-TOP!**

COMMUNITY SPOTLIGHT

Meet Matt Reed, American maker extraordinaire

86



YOUR PROJECTS

32

WIZARD CHESS

Magic chess. Like Harry Potter, only real!

MONOME PI 34

A glockenspiel powered by a Pi

PIANOLA 36

An old-school, self-playing piano

TEEFAX 38

Relive the glory days of Ceefax

REGULARS

> NEWS 06

> TECHNICAL FAQ 66

> BOOK REVIEWS 82

> THE FINAL WORD 96

COMMUNITY

> THIS MONTH IN PI 84

What else happened this month in the world of Pi?

> EVENTS 88

Find a community event near you

> MEET A JAM ORGANISER 90

We talk to Les Pounder of the Blackpool Jams

> LETTERS 92

We answer your letters about the magazine and Pi

REVIEWS

> PUPPET KIT 76

> FORMCARD 78

> MCROBOFACE 79

> ZERO SEG 80

> ZERO LIPO 81

ASTRO PI BLASTS BACK INTO SPACE

Brand-new European mission for Astro Pi units sees students across Europe developing code for Ed and Izzy

ESA astronaut Thomas Pesquet is challenging school students across Europe (credit: ESA/NASA)

SIGN UP FOR ASTRO PI

Students and teachers should first assemble a mission team, which must include at least one support teacher as well as students under the age of 16. Use the Mission Plan Template (**magpi.cc/2enYSWP**) to design a sample mission that showcases your approach to running a space mission, and demonstrates that you can break down your big idea into concrete steps.

The deadline for the first round of applications is 13 November 2016.

Teams from France should register in French through the Centre National d'Études Spatiales: **magpi.cc/2eo1zYh**.

Teams from Poland should register in Polish through ESERO Poland: **magpi.cc/2dUyJya**.

Teams from the other ESA Member States should register and upload their mission plan (in English) with ESA: **magpi.cc/2eo3Fre**.

If you're looking for inspiration, take a look at the winners from Tim Peake's Astro Pi mission (**magpi.cc/2eo258N**).

The European Space Agency (ESA) and the Raspberry Pi Foundation have teamed up to run a brand-new Astro Pi challenge.

Space cadets will get another chance to create code for Ed and Izzy, the two Astro Pi units on board the International Space Station (ISS). For this mission, students from France, Spain, Germany, and other European countries will join young coders from Britain.

This time around, ESA French astronaut Thomas Pesquet will run code on Ed and Izzy.

Thomas is ready to blast into space in November 2016. He will serve on board the ISS as a flight engineer for Expeditions 50 and 51.

"I'm currently at the European Astronaut centre," he told us. "I'm training for my Proxima mission. I'll be going to the International Space Station this autumn, for six months."

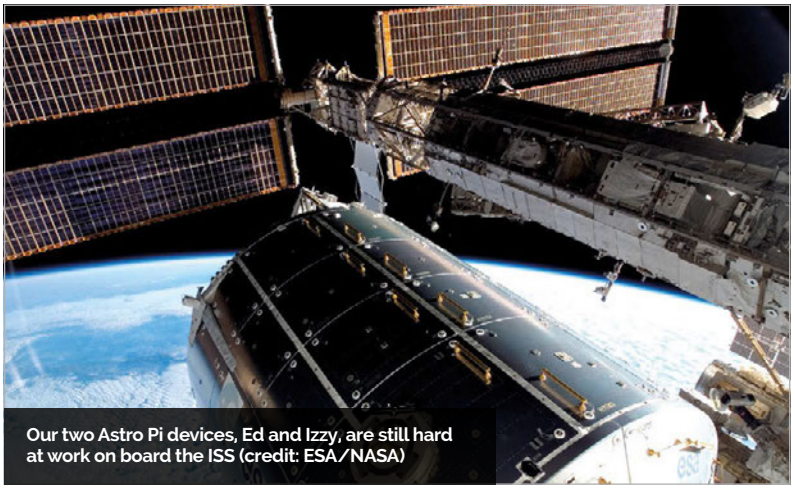
All aboard the ISS

"We have a Raspberry Pi computer on the International Space Station, which is being programmed by school students," said Dave Honess, programme manager for Astro Pi.

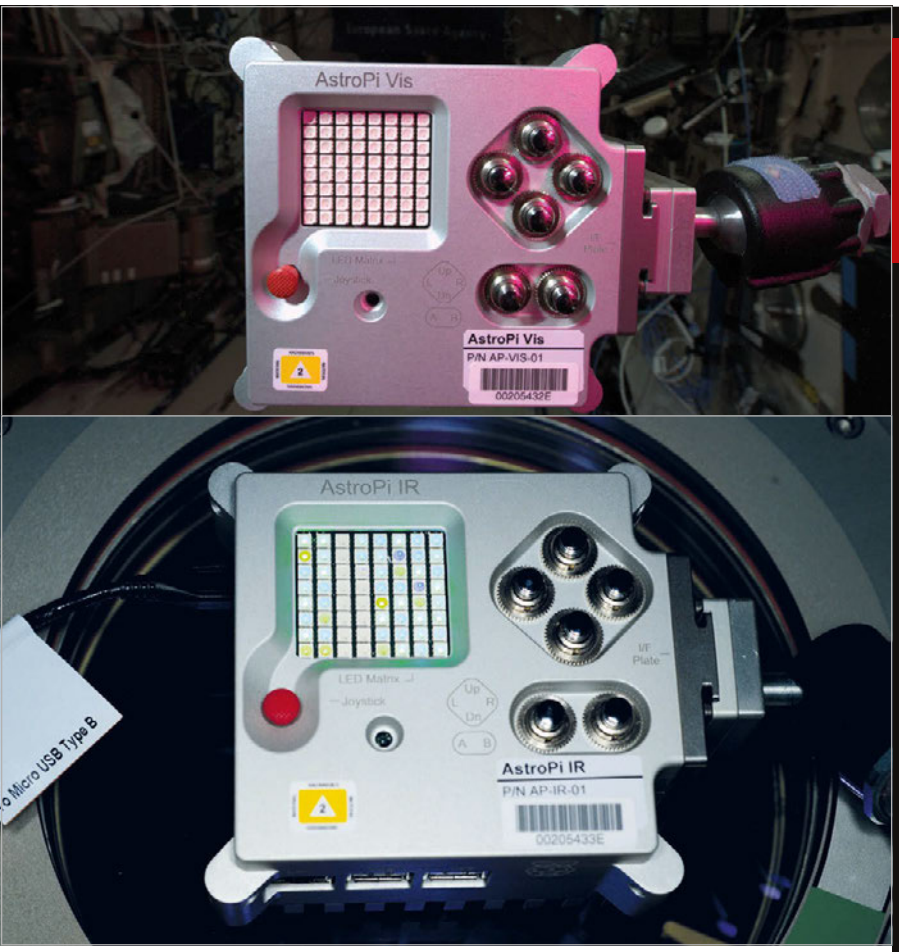
"Think about how profound that is for a school student," continued Dave, speaking at the Space for Inspiration conference. "You can have something you've made up in space; that's what Astro Pi is."

Getting the Astro Pi devices on board the ISS in the first place was no easy feat for the Raspberry Pi Foundation, so it's fantastic to see them doing a second mission. "If you want to fly anything to the International Space Station, even if it's a small payload, you have to have something called a Flight Safety Certificate (FSC)," said Dave. "Our FSC was quite hard to get, because as an educational payload we were quite unusual."

The Astro Pi units went up for Major Tim Peake, a British ESA



Our two Astro Pi devices, Ed and Izzy, are still hard at work on board the ISS (credit: ESA/NASA)



Astronaut. Tim manually uploaded code, developed by UK school students, to the boards.

Before Tim left the ISS, he plugged in an Ethernet cable to the Astro Pi devices. "So we now have space-to-ground communications with the Raspberry Pi," said Dave. "We can remotely access it to deploy new student code and download experiment results, which we didn't have in Tim's mission. He had to take the SD card out and plug it into a laptop, which was time-consuming."

Above Ed and Izzy, the two Astro Pi devices flying on the ISS (credit: ESA/NASA)

> "We now have space-to-ground communications with the Raspberry Pi"

Ed and Izzy flying high

"My friend and fellow ESA astronaut Tim Peake just finished up his ISS mission," said new astronaut Thomas. "He has left two very special items on board for me: two Astro Pi computers."

Each Astro Pi contains a standard Raspberry Pi 2 and a Sense HAT. "So get ready," continued Thomas, "since a lot of exciting science can be done with the Astro Pis. I'm very glad to invite you to join the Astro Pi School Challenge. I will challenge you to run a coding competition, based on the mission that I will assign you.

"You may even have the chance to send your code to the Astro Pi on the ISS, where it will run in space," said Thomas. "Have fun learning. I can't wait to see all the code that you come up with. So, see you soon!"

ASTRO PI IN NUMBERS

£25 COST OF A RASPBERRY PI

400km ABOVE THE EARTH

£2,500 COST OF EACH ASTRO PI FLIGHT CASE

£4,000 COST OF ETHERNET CABLE FOR SPACE-TO-GROUND COMMUNICATION

8,000 RESPONDED TO ESA'S **'DO YOU WANT TO BE AN ASTRONAUT?'** AD

£72 BILLION ESTIMATED VALUE OF ISS

PEUGEOT CITROEN USING RASPBERRY PI ROBOTS TO BUILD CARS

Robot controlled by Raspberry Pi carries cars around the factory

The Raspberry Pi is taken incredibly seriously in engineering, with thousands of our favourite computers embedded in industrial projects around the world.

Peugeot Citroën has taken the Raspberry Pi to heart. The company is using Raspberry Pi boards to revolutionise the way it builds cars.

The jewel in its crown is this automatic guided vehicle (AGV) used in its Portugal factory. We spoke to Pedro Lopes, manager of the engineering department. "In our weld shop, the cars are transported in a wheeled iron structure that we call 'the chariot'," he tells us.

Vítor Duarte, Peugeot Citroën's weld shop manager, challenged Pedro to build a low-cost, but reliable, solution for carrying the chariots "without using human hands". The manager of IT infrastructure, Carlos Mesquita, sponsored the project. "He's a believer in these types of solutions," says Pedro. The Raspberry Pi AGV was born.

Below Rui Peixoto, Pedro Lopes, and Gonçalo Marques stand on top the AGV in the Peugeot Citroën factory

The Raspberry Pi and other components live inside the white box on the front of the robot

"Our metalworkers made the completely iron structure," recalls Pedro. "At the same time, the programmers, who are all Raspberry Pi fans, started to choose the components and began writing the code."

The result is a giant, autonomous robot, which is used to lift and move cars around the Peugeot Citroën factory.

Chariot driving

The AGV contains a Raspberry Pi, a touch display, a 12-channel USB servo controller, and a RoboClaw ST 2x45A motor controller (which drives the two DC motors).

A Roboteq MGS1600 magnetic band sensor is used to guide the AGV along the track that runs around the factory. "It travels 36 metres per cycle," says Pedro. "We currently have a production of 220 cars per day; it travels 7,920 metres per day."

The robot sports a RoboPeak RPLIDAR 360° scanner for safety. "The RPLIDAR is used for people detection," explains Pedro. So the AGV will stop automatically if a person is in its way.

HANDS-FREE WITH ALEXA

The Alexa Voice Service (AVS) API for Raspberry Pi now includes hands-free functionality.

"Any digital maker using the free API from the Amazon Developer team had to add a button to their build, putting a slight dampener on the futuristic vibe of the disembodied Alexa," writes Alex Bate, Raspberry Pi's social media editor. "We know about this because a bunch of you [makers] complained about it."

This update removes the press-a-button limitation. Makers can now use Alexa by issuing a wake word, calling out to "Alexa", "Echo", or "Amazon".

If you're looking for ideas for builds, check out the Internet of Voice Challenge that Raspberry Pi and Hackster hosted (**magpi.cc/2baErdf**). Winning builds included a voice-activated Baseball Pitching Machine, a voice-controlled K'nex Car, and a Smart Cap for the visually impaired.

Above The update to Amazon's Alexa API now enables Raspberry Pi makers to create hands-free devices similar to the Amazon Echo Dot

BUILDING A HUMAN MACHINE INTERFACE

Troy Miller, applications engineer at Galil Motion Control, has developed a human machine interface (HMI) using Galil software and a Raspberry Pi

The result is a cheap, powerful HMI perfect for industrial environments, without having to use a full-sized PC.

"There are many sources for HMIs, and many can cost thousands of dollars," says Troy. The Raspberry Pi is a much cheaper option, but it also comes with a 7-inch touch display, and now it can run Galil's motion-control software.

"This powerful trio forms the foundation for an inexpensive but fully capable HMI, customised for any motion-control application," says Troy.

"There are free software tools that can allow a person to create just about any interface to run on the Raspberry Pi," he adds. "The software acts as the glue to take in the input from the user in the touch interface, and the Galil gclib API translates those simple instructions into the commands to send to the machine motion controller."

Troy has made an excellent video demonstration of a Raspberry Pi running Galil software to control a stepper motor linear stage (**magpi.cc/2dSXGYu**).

NOW TRENDING

The stories that made waves on our social media sites this month

TOP 50 magpi.cc/2dT4FAM

We were taken aback by the sheer weight of community love for the Top 50 feature (from *The MagPi* issue 50). Our Top 50 photo album got a huge amount of attention on Facebook.

ZERO 360 magpi.cc/2dT2Qnk

This project generated lots of love on Twitter. James Mitchell's ingenious device can take 360-degree panoramas and even time-lapses. It features eight Pi Zeros equipped with Camera Modules, placed around a laser-cut wooden housing.

PIPER REVIEW magpi.cc/2dT46qz

Rob's review of the crowdfunded laptop that gamifies the hardware building process piqued the interest of our lively Google Plus community.

ROYAL RASPBERRY

Raspberry Pi community invited to meet the Duke of York at St James's Palace

Below Tom Hartley, president of Imperial College Robotics Society; Amy Mather, winner of European Commission's Digital Girl award; and Matthew Timmons- Brown, The Raspberry Pi Guy

Lucky members of the Raspberry Pi community attended a special event at St James Palace on 5 October.

The Duke of York, HRH Prince Andrew, invited members of the Raspberry Pi community to the event to celebrate all the good work that they do.

Invitees were free to mingle with members of the community, and learn about Code Club and Raspberry Jam events, while taking in the splendour of the palace.

There were inspirational speeches from the Raspberry Pi Foundation CEO Philip Colligan, Code Club UK co-founder Clare Sutcliffe, and The Duke of York himself.

"The event at St James's Palace was an opportunity for us to celebrate the awesome achievements of our community of makers, educators, volunteers, and young people," says Philip Colligan. "More than anything, Raspberry Pi is a community and we really just wanted to say thank you for everything they do."

Right Hannah Belshaw, from Cumnor House Girls' School in Croydon, was an Astro Pi winner with her idea to represent data from the Astro Pi in the world of Minecraft

Below Maria Quevedo, Clare Sutcliffe, and Rik Cross from Code Club UK

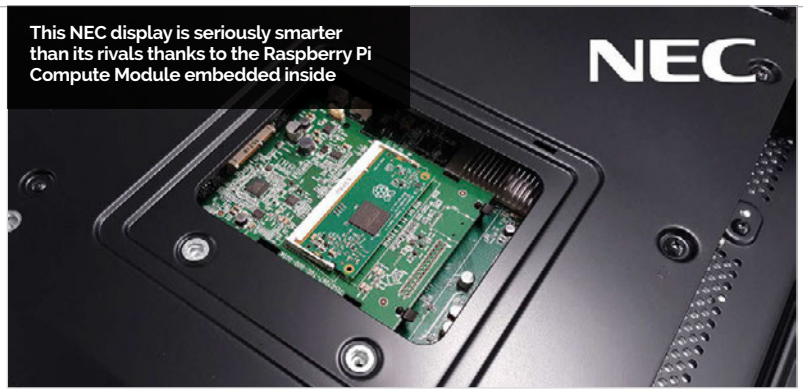
> "More than anything, Raspberry Pi is a community and we really just wanted to say thank you for everything they do"

Grand old duke

"The Duke of York is patron of the Raspberry Pi Foundation and was also the patron of Code Club before we merged," explains Philip. "So he hosted the event and gave a heartfelt speech about the importance of computing and digital making education."

Places for the event were extremely limited. "The only downside was that we could only fit 150 people in the room," Philip tells us, "and, of course, our community is much, much bigger than that. That's why we're always thinking of more ways to celebrate and support our community to grow and achieve more."

The event came shortly after the news that the Raspberry Pi had sold over ten million units in total. It was a great opportunity to reward some of the community that had made this British computer such a success story.



This NEC display is seriously smarter than its rivals thanks to the Raspberry Pi Compute Module embedded inside

NEC DISPLAY WITH PI INSIDE

Custom Raspberrry Pi Compute Module makes new NEC display super-smart

NEC has announced a new display with a Raspberry Pi 3 Compute Module inside.

"We think that the large-format NEC displays will be suitable for a very broad range of applications," says Eben Upton, CEO of Raspberry Pi Trading. "Obviously digital signage applications, but there are also opportunities for interactive presentations and a broad range of IoT projects."

The Raspberry Pi Compute Module comprises the guts of a Raspberry Pi 3 board. Other projects can have a Raspberry Pi embedded inside.

NEC has customised the Compute Module with a larger than usual 16GB of flash storage.

"People are using Raspberry Pis to add intelligence to their products," explains Eben. "We've been fortunate enough to have sold 10 million Raspberry Pis so far, and the commercial success has led to the third generation of a more mature and powerful technology which can be used with NEC's intelligent display."

Developer powered

"Our work on the Raspberry Pi mini-computers is driven by the huge community of developers," continues Eben. "Overall, this collaboration shows NEC's confidence with our ability to provide a platform that can be used in a variety of environments."

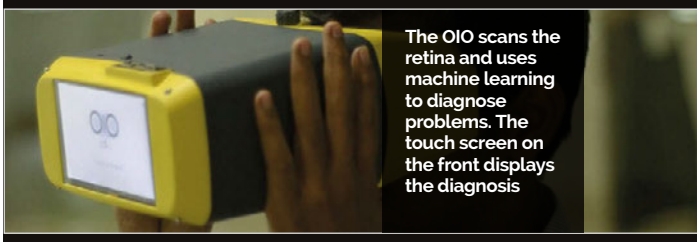
"Integrating the Raspberry Pis with our displays will provide businesses with advanced technology suitable for digital signage, streaming, and presenting to enhance the overall visual experience at an affordable price point," says Stefanie Corinth, senior VP marketing & business development at NEC Display Solutions.

"It's an incredible vote of confidence in the Raspberry Pi Compute Module platform from a blue-chip hardware vendor, and will hopefully be the first of many," concludes Eben.

Below The displays are designed for public signage and presentations; the range starts at a 40-inch size

OPEN INDIRECT OPHTHALMOSCOPE

This ultra-low-cost eye screening device uses machine learning to save eyesight in India


The OIO scans the retina and uses machine learning to diagnose problems. The touch screen on the front displays the diagnosis

The Raspberry Pi is being used to save the eyesight of people in India thanks to the Open Indirect Ophthalmoscope (OIO) project.

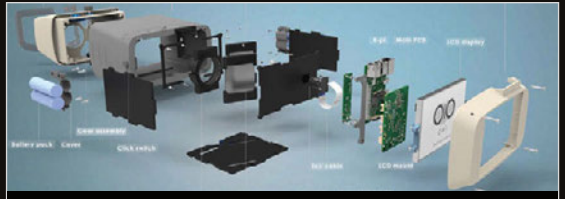
"The OIO is a portable retinal camera that uses machine learning to make diagnosis not only affordable but also accurate and reliable," explains Sandeep Vempati, a mechanical engineer at the Srujana Center for Innovation. The device uses a Raspberry Pi to drive down the cost of diagnosis.

"Currently, visual impairment affects 285 million people worldwide," reveals Sandeep. "What's more surprising is the fact that 80 percent of all visual impairment can be prevented, or cured if diagnosed correctly."

"India is the diabetic capital of the world," says Dr Jay Chhablani, a retinal disease specialist. "Diabetics affects the retina and leads to something called 'diabetic retinopathy'. If we see the patient at an early stage of diabetes, we can treat these patients by controlling diabetes and applying laser treatment."

"3D printing creates the OIO for a fraction of the cost of conventional devices, and yet maintains the same quality," says Sandeep. The OIO costs $800 to build. Conventional retinal cameras cost ten times as much.

OIO's Hackaday page (**magpi.cc/2dVtqfN**) lists the required components. "Engineering feels great when you see a product being useful in the real world," enthuses Sandeep.


The case is 3D printed, and the components are low-cost and widely available. The project is open-source so anybody can build one

MEET THE WINNERS OF PIIOT SMARTER SPACES

Element14 tasked makers with creating an IoT command centre using a Pi 3

The element14 Raspberry Pi community is a pretty amazing place, especially if you want to catch some great Pi-related maker projects. In the past we've featured projects straight from here, like a super-scary haunted door and even a Pi Zero soldered into a CRT TV for retro gaming. Recently, the community held a design challenge called PiIoT, with the aim to create 'Smarter Spaces with Raspberry Pi 3'. Using a Pi 3, contestants were tasked with creating a better command centre for all their IoT devices in a specific area. The winners were announced just after we went to print last issue, but they're pretty cool so we thought we'd introduce you to them now!

And the winners are...

Plant health smart camera

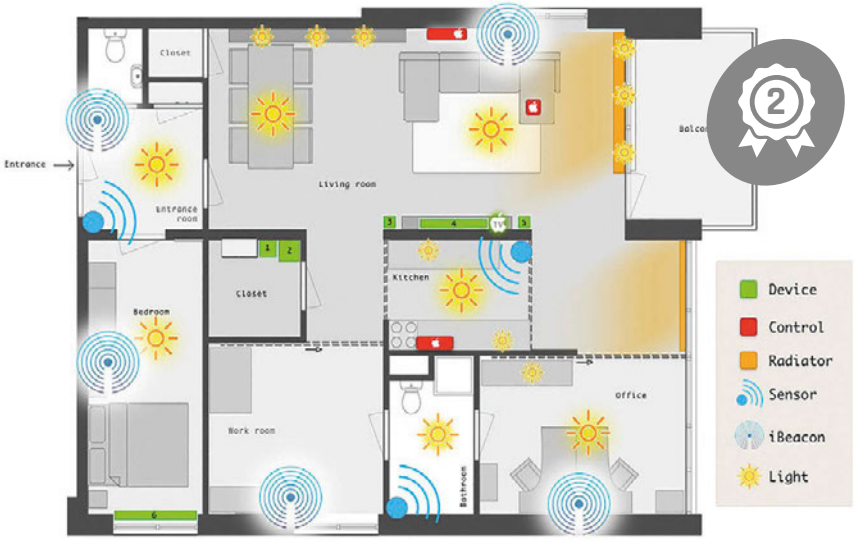
Maker: Gerrit Polder
magpi.cc/2ej7RnP

Gerrit's project isn't even about an IoT home, but an IoT farm. This project uses two Pi Camera Modules, a normal one and a Pi NoIR camera, along with OpenCV to track plant health. It's a contained system with a purpose-built display and a slave Raspberry Pi Model B+ to operate the other camera. This method uses the same technique as the Enviro Pi experiment that was carried out on the ISS for Astro Pi: Normalized Difference Vegetation Index (NDVI). The images are combined in this method, which can then be reviewed on the system itself.

Thuis

Maker: Robin Eggenkamp
magpi.cc/2ejjbjS

Thuis is a full home automation system with the Raspberry Pi at the core. The original brief was to have a smartphone greet you as you get home, and to have the house react as you move through it. This has been accomplished, with lights turning on as you enter rooms and a custom UI that lets you control lighting, music, and other media aspects throughout the home. It's a very powerful and complex system; Robin has also put together some fantastic documentation for it if you wish to follow in his footsteps.



Below A simple interface for Thuis that controls many parts of the house

IoT Alarm Clock

Maker: Frederick Vandenbosch
magpi.cc/2ej74n5

This IoT Alarm Clock is something slightly simpler: it's a control unit that lives in Frederick's bedroom. While primarily an alarm clock, it also has access to the IoT network in his house. It also has a sister unit in the living room, and includes a full screen for slightly more precise control. Both units can control the IoT devices in the house, which comprise a cat feeder, a special tower light in Frederick's garage to notify him if he's needed, a set of Philips Hue lights, and a couple of other bits around the house.

The judges really liked the hand-built wooden enclosures for the project, and the excellent interface he built to go with it. Apparently, Frederick also moved during the time he was building his entry, which is a very impressive feat. His efforts won him a 3D printer, which will definitely help him in the future.

DESIGN CHALLENGES

Element14's community has regular challenges that people can enter – PiIoT was the second of the year – and they always have pretty good prizes, too. PiIoT's first prize was a 3D printer, and the runners-up managed to go home with a huge selection of kit, including some power tools. Keep an eye out on the element14 contest pages for the next round: **magpi.cc/2ejj9bB**.

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TO EXPLORE
With an included SD card preloaded with the Project Spaces installer, the WD PiDrive Foundation Edition lets you create independent work spaces for multiple projects on a single drive so you can switch between your creations on the fly.
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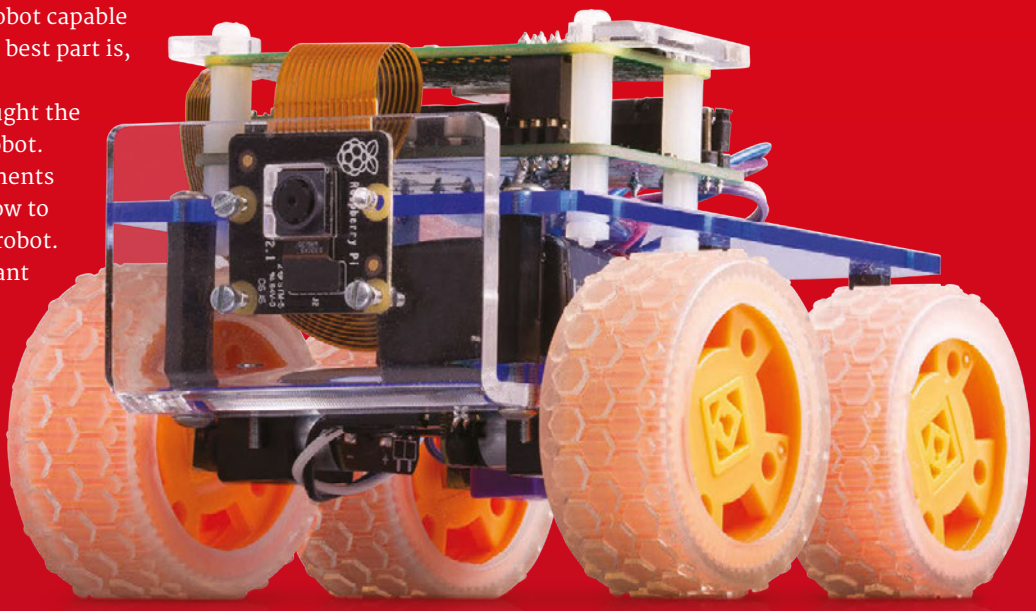
BUILD A REMOTE CONTROL ROBOT

Make a Pi Wars-winning robot with our expert **Brian Corteil**

This is no ordinary robot build. Over the next few pages, we are going to show you how to design, build, and program a robot capable of winning a robotics competition; the best part is, anyone can make one!

In this feature, we will take you thought the steps required to build this amazing robot. We'll look at different types of components you could select, how to program it, how to build it, and then how to control your robot. We'll even have some tips for if you want to enter your robot into a competition. Read on and we can get started...



SELECT YOUR STYLE

What kind of robot do you want to make?

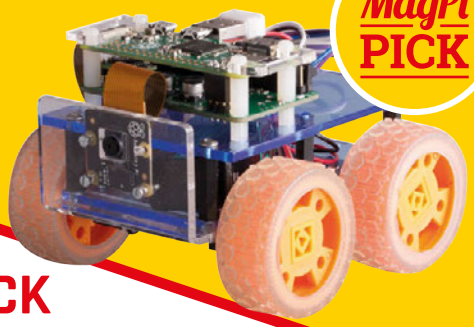
Robots come in many configurations. The type we will be looking at are commonly called rovers (ROV or remotely operated vehicle). There are many types of rovers, including the classic two-wheel tail dragger, omnidirectional, tank tracked, four-wheel, and the six-wheel Mars rover. Each type has its pros and cons.

FOUR-WHEEL DIRECT DRIVE

This is the robot we're building. The four-wheel direct drive chassis is a common design for a robot, and can be bought as a kit from many stores. Four-wheel direct drive robots have many advantages over two-wheeled robots: they have more torque, more grip, they're faster, and are able to turn on the spot. This makes the robot nimble and very suitable for challenges like the maze and the obstacle course.

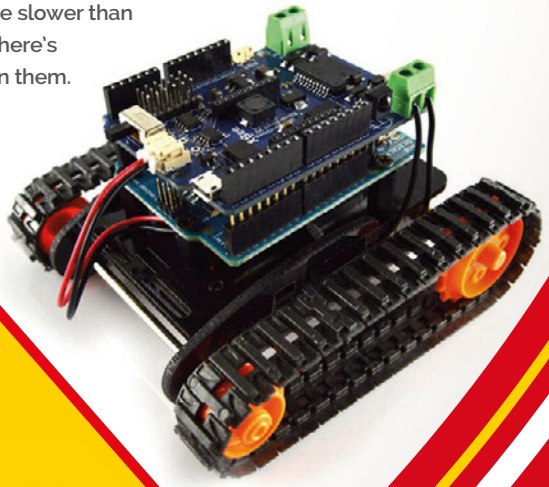
Disadvantages include a higher cost due to the greater number of motors and more expensive motor controller to use them.

The MagPi PICK



TANK TRACK

Tank tracks are cool. They have loads of grip when matched to the surface you are running on, are great over rough ground, and you can turn on the spot. However, they can difficult to build. The alignment of the tracks needs to be spot on when installing them, or you will risk the track slipping off. Tracks can also be slower than wheels because there's more friction on them.

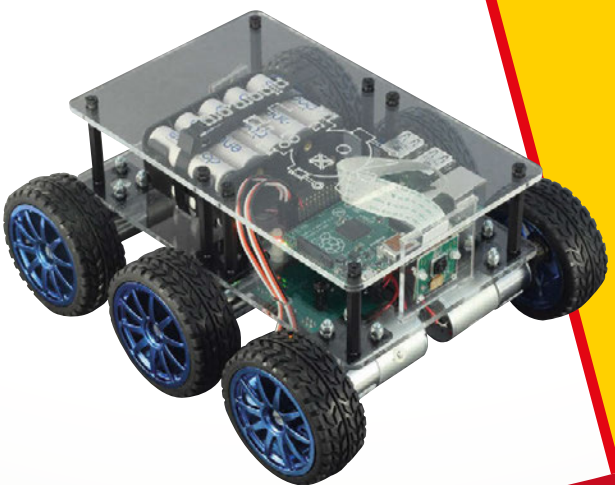


OMNI

Omnidirectional robots are great for avoiding your opponent in sumo-style contests like Pi Noon at Pi Wars, as they can move in any direction. The downside is they are not so great on rough ground due to the design of their wheels. The wheels are complex and can be quite expensive to buy, and you'll need to do a lot more coding on them. The maths behind getting it to work can be very cool, but it's also scary enough to make you want to run and hide behind the sofa.

SIX WHEELS

Six-wheel direct drive robots have most of the advantages of both tracked and wheel robots, offering good grip, high torque, and manoeuvrability. The use of multiple motors balances their output. Disadvantages for this type are the cost of six motors, wheels, and a motor controller powerful enough to supply the juice required.



PICK YOUR MOTORS

How will the robot get around everywhere?

Motors come in many sizes, types, with/without gearboxes, etc. Common motor types used in maker projects are brushless, brushed, and stepper (see more details on the right). When selecting a motor, you need to consider its voltage rating, free-run current, stall current, and type. The free-run (or operating) current is how much current the motor will draw when running; with this information, you'll be able to estimate how much power the robot needs.

This is important for a reliable design, as you'll need to match the motor and controller characteristics; if you use a motor that has a voltage rating higher than the motor controller, you won't get the full potential out of the motor. If the stall current is higher than the controller's peak output current, you'll see 'magic smoke' come from the controller, which is bad. Another characteristic of the motor you need to consider is its speed: the higher the RPM of the motor, the faster it will turn the robot's wheels/tracks. For this robot, we're using the micro metal 6V N20 motors from Pimoroni.

MOTOR TYPES

BRUSHLESS

PROS:
- ⊕ No brushes to wear out
- ⊕ More torque
- ⊕ More power
- ⊕ Better control
- ⊕ Power-to-size ratio

CONS:
- ⊖ Complex & expensive controls
- ⊖ Less rugged
- ⊖ Cost

BRUSHED

PROS:
- ⊕ High torque at lower speeds
- ⊕ Simple control circuits
- ⊕ Cost

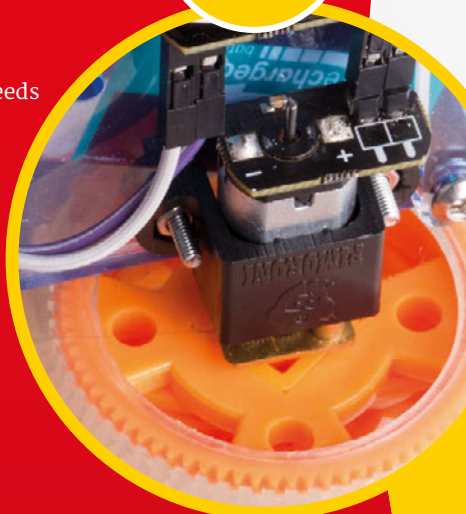
CONS:
- ⊖ Shorter operational life
- ⊖ Power-to-size ratio

STEPPER

PROS:
- ⊕ Precise control (turns in small steps)

CONS:
- ⊖ Complex controls
- ⊖ Cost
- ⊖ Slow

Our tiny robot is using this tiny micro metal brushed motor



MOTOR MARKINGS

MOTOR MARKINGS

Some things you'll see on a motor...

DC: 12V

The rated voltage of the motor. Can also be shown as '12V DC'. DC means that the motor must be powered by a direct current source like a battery.

RPM

Revolutions per minute. Can also be shown as r/min. The lower the number, the slower the motor is, so 500 rpm is faster than 25 rpm.

GEAR BOX RATIO

Not pictured on this motor. If a motor output is described as a ratio, the lower the number, the faster the motor, so 50:1 is faster than 254:1.

SELECT A MOTOR CONTROLLER

Now we have motors, we need a way to use them

Motor controllers, like the name suggests, are used to control motors. There are many types available for the Raspberry Pi, so when selecting the motor controller, you need to match the controller to your motors. An important consideration in this selection is the support documents, libraries, and software examples. Features to look out for are inputs, outputs, servo control, and whether or not it can power the Pi from a single power source. The controller you select must be able to handle the battery voltage, the peak current of the motors when stalled, and be compatible with the Raspberry Pi.

MOTOR CONTROLLER SPECS:

Peak current: How much current the driver will tolerate before releasing magic smoke

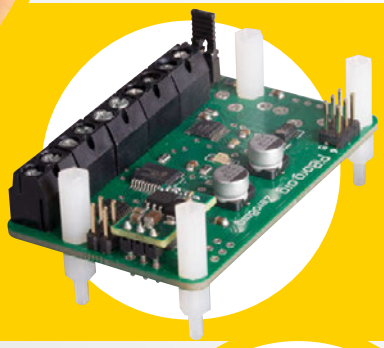
Drive voltage: Voltage used to drive the motor(s)

Drive current: Constant current the driver chip can maintain

Logic voltage: Voltage the logic must be driven at to function

Logic current: Current required to function

SOME CONTROLLERS TO CONSIDER:



ZEROBORG piborg.org/zeroborg

The MagPi PICK

The ZeroBorg is the controller we're using in this project. It has a number of features that make it stand out from some of the other boards, such as its use of two TI DVR 8833 H-bridges which allows for independent control of up to four motors. This makes it good for controlling an omnidirectional robot, or two stepper motors. You also can add/specify a DC-to-DC converter to power both the motors and the attached Raspberry Pi Zero. One final feature is the IR receiver, so you can control your robot with an IR remote control.

PICON ZERO magpi.cc/1p9wGaA

A well-thought-out Pi Zero format controller from 4tronix, it uses the same TI DRV8833 motor driver H-bridge chip as the ZeroBorg. The extra inputs and outputs are great for adding sensors, servos, and NeoPixels; there's even a dedicated socket for an HC-SR04 ultrasonic sensor! The power arrangements are very flexible, as you can drive the motors from the Pi's 5V rail or from a separate power source, from 3V to 11V. It's also worth checking out 4tronix's RoboHAT if you're using a full-sized Pi.

EXPLORER PHAT magpi.cc/1Pk5SdN

The Pimoroni Explorer pHAT was the first Pi Zero-format motor driver HAT, and is an excellent controller. It uses the TI DVR8833 H-bridge again and has four 5V-tolerant digital and analogue inputs, plus four 500mA outputs. The various inputs give options for connecting different types of sensors, and the motor driver will happily drive a pair of N20 metal gear motors. For a full-sized Pi, use the Explorer HAT Pro.

POWER YOUR ROBOT

The perfect batteries to get your robot moving

The correct battery can make a huge difference to your robot. It all comes down to four types for robots: lithium-ion, NiCad-based, lead acid, and dry cells. Battery technology has improved a great deal in recent years, thanks to the development of mobile phones, laptop computers, and tablets, with their requirement for high power and increased standby life. Whichever battery type you use, you'll need a battery holder to connect them.

NICAD / NIMH
(nominal cell voltage 1.2V)

NiCad / NiMH batteries were the number one choice before the rise of the lithium-ion batteries, due to their power-to-weight ratio and a predictable discharge voltage that changes little from 1.2V per cell until it nearly runs out. They're packaged in common battery sizes, including AAA, AA, and PP3. Chargers are also commonly available, even being sold in supermarkets. The discharge rates are not as high as a lithium battery, but they don't have a flammable metal in their construction. We're using this type for our robot.

The MagPi PICK

LITHIUM-ION INCLUDING LIPO
(nominal cell voltage 3.7V)

Lithium-ion-based batteries offer some of the highest energy density and energy release available. This means a robot powered in this fashion can use a smaller, lighter battery. Lithium batteries are more dangerous, though. There are two types of lithium batteries: type one has built-in safety circuits, to protect against under- and over-voltage and short circuit. Type two batteries have no safety circuits! If you wish to upgrade your robot to LiPo, make sure to be safe.

LEAD ACID
(nominal cell voltage 2V)

The granddaddy of all rechargeable batteries, the lead acid battery was invented in 1859 by Gaston Planté. This type of battery has a very low energy density and is made of lead. This makes it a poor choice for use in a robot, although it can supply high surge currents. While larger lead acid batteries are used in most cars, they're best ignored for this project due to their high weight and low energy density.

DRY CELL
(nominal cell voltage 1.5V)

Zinc-carbon and alkaline are the more common types of dry cells, widely available in common battery sizes, including AAA, AA, and PP3. Although not rechargeable, they're useful as an emergency replacement for NiCad / NiMH; however, you need to be careful with the increased voltage. They're also expensive to continually replace.

CHOOSE A RASPBERRY PI

Finally, choose your computer

When it comes to choosing which Raspberry Pi to use in your robot, there are two Raspberry Pi models that are perfect for the role: the Pi Zero and the Raspberry Pi 3. The Model A is a close third due to its size and low power requirements, and the eventual Pi 3 Model A with on-board radio chip will make that an excellent choice in the future.

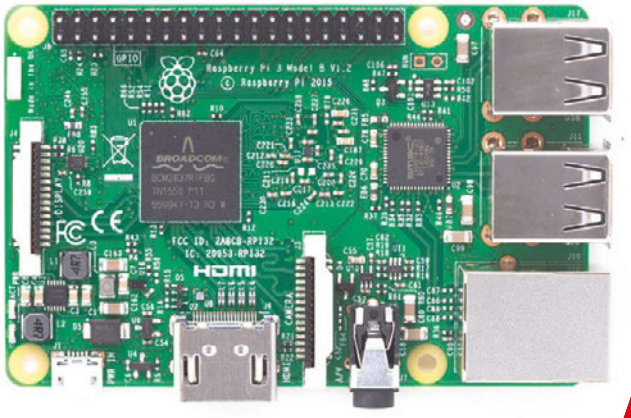
The Pi Zero is a great choice for a robot because of its even smaller size, along with its low power requirements. The Raspberry Pi 3 is the most powerful Pi to date, with 1.2GHz CPU, 1GB of memory, plus built-in wireless LAN and Bluetooth, leaving the four USB sockets free. The Raspberry Pi 3 makes sense for highly demanding applications like computer vision and multi-threading, but it will use up more power.

PI ZERO

PROS:
- ⊕ Very small
- ⊕ Very cheap
- ⊕ Low power consumption
- ⊕ More powerful than a Model A+

CONS:
- ⊖ Limited USB connectivity
- ⊖ Needs more soldering for GPIOs
- ⊖ No on-board wireless or Bluetooth

The MagPi PICK



RASPBERRY PI 3

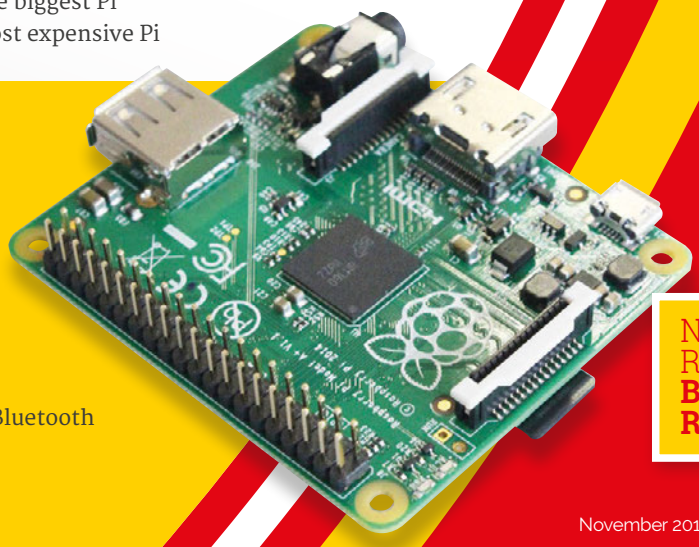
PROS:
- ⊕ The most powerful Pi
- ⊕ Relatively low electricity requirement
- ⊕ 4× USB ports
- ⊕ Wireless LAN and Bluetooth

CONS:
- ⊖ Higher power consumption than other Pis
- ⊖ The biggest Pi
- ⊖ Most expensive Pi

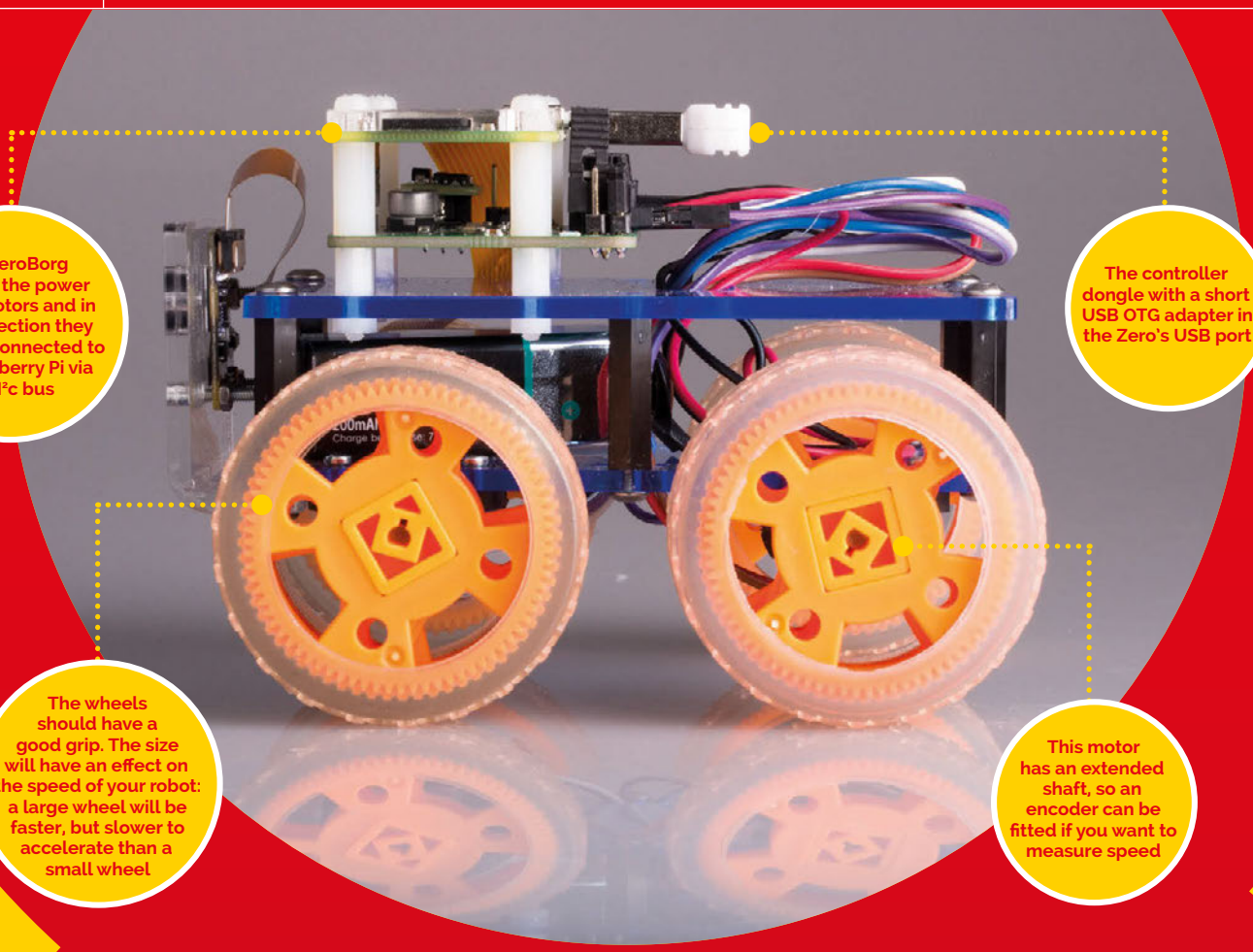
MODEL A+

PROS:
- ⊕ Fairly small
- ⊕ Low power consumption
- ⊕ Standard-size USB port

CONS:
- ⊖ Bigger than Pi Zero
- ⊖ Only one USB port
- ⊖ No on-board wireless or Bluetooth
- ⊖ Least powerful Pi



NOW WE'RE READY TO **BUILD A ROBOT!**


The ZeroBorg controls the power to the motors and in what direction they turn; it is connected to the Raspberry Pi via the I²c bus
The controller dongle with a short USB OTG adapter in the Zero's USB port
The wheels should have a good grip. The size will have an effect on the speed of your robot: a large wheel will be faster, but slower to accelerate than a small wheel
This motor has an extended shaft, so an encoder can be fitted if you want to measure speed

DESIGNING THE CHASSIS

Now we have all the parts, they need to attach to something

The chassis for a robot needs to be strong and light, and have enough space to fit all the parts on it. For something like Pi Wars, there's an additional requirement for the robot's footprint to be less than 300 × 225mm.

Start by laying out the parts you already selected on a piece of paper the size of, or smaller than, the footprint you are building to. If you don't already have all the parts, you can model them in 3D or CAD software, or even cut them out of paper. This will give you an idea of what size your robot will need to be, and what clearance the wheels require. It also helps to think where and how additional sensors attach to your chassis.

In addition, you'll need to think about how to add and remove parts for different challenges. The distance between your robot's wheels will affect how your robot will turn/handle: if the wheel base is longer than its width, the robot will turn more slowly. This could be an advantage in a speed run challenge, as it would make it harder for the robot to turn and hopefully help keep it on track.

You also need to think about the clearance height from the surface your robot is standing on to the bottom of your motors/chassis. The higher it is, the better your robot will be at clearing obstacles. It's also a good idea to keep most of the weight low down in your design; this will stabilise your robot and make it less likely to topple over.

One of the most important things to think about is how easy will it be to change or charge your battery.

PRE-MADE ROBOT CHASSIS

Download our files so you can make the rover from our cover!

If you don't fancy designing a chassis just yet, we've got some files you can use. They're for the robot we've built; it's made up of two Perspex plates, with 3mm PCB spacers joining the two together. The motors and battery are fitted on the bottom plate, with the motor controller and Raspberry Pi mounted on the top plate. This creates a box, making a light and strong chassis with plenty of space for all the components, along with any sensors to be added in the future. The plates are laser-cut for this project, but they could also be 3D-printed or even cut and drilled by hand.

HOW TO MAKE THE CHASSIS

For the chassis plates, you'll have to get them laser-cut – or cut them out yourself – from 3mm plywood, MDF, or Perspex (acrylic). It's also possible to convert files for 3D printing.

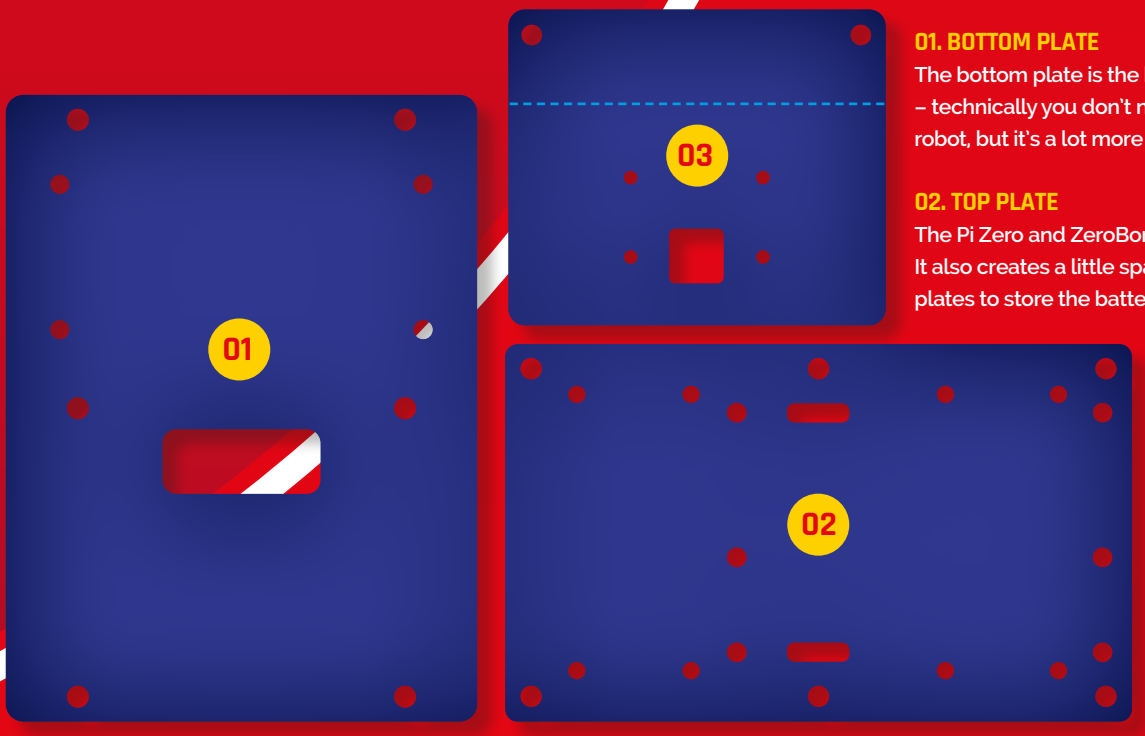
You can download a PDF for the plates from GitHub (**magpi.cc/2dx82hO**). You'll also find a DXF file, plus the original Inkscape SVG files, so you can modify the design if required. Your local makerspace, hackspace, or fab lab may be able to help cut the plates. In the UK, there's also Eagle Labs. There are other online laser cutting services – try searching for 'laser cutting services' in Google and look for local ones. A top tip to remember: the plates' edges should be cut last on the laser cutter.

RESOURCES:

CHASSIS FILES
MagPi robot chassis files: **magpi.cc/2dx82hO**

PLACES TO BUILD THE CHASSIS
Hackspaces and makerspaces: **magpi.cc/2dxbnxr**
Eagle Labs: **labs.uk.barclays**
Fab Labs UK: **fablabsuk.co.uk**

ONLINE SERVICES
RazorLAB: **razorlab.co.uk**
Laser Make: **lasermake.co.uk**
Perspex (acrylic) supplier: **kitronik.co.uk**



01. BOTTOM PLATE
The bottom plate is the biggest part of the chassis – technically you don't need the top plate for this robot, but it's a lot more sturdier with it on

02. TOP PLATE
The Pi Zero and ZeroBorg are mounted on this. It also creates a little space between the chassis plates to store the battery

03. CAMERA MOUNT
The camera mount needs to be bent along the line going through it, so it can be mounted underneath the bottom plate while still having the camera face forward

BUILDING THE ROBOT

Get your screwdriver handy, as it's time to make your robot

PARTS LIST:

Major components:

Raspberry Pi Zero
(v1.3 if adding a camera)

PiBorg ZeroBorg complete
piborg.org/zeroborg

Chassis plates

4× 50:1 micro metal gear motors
magpi.cc/2eynuNk

4× Pimoroni motor brackets
magpi.cc/2dW6NYR

4× wheels
magpi.cc/2eq0Npp

USB to micro-USB OTG Converter Shim
magpi.cc/1JT9aZc

Wireless controller – we used the PDP Rock Candy
magpi.cc/2dvjKJS

Connectors and fasteners:

PP3 battery clip
magpi.cc/2ebjlgV

PP3 rechargeable battery

Female-to-male jumper wires
magpi.cc/2dvjMSb

6× 3mm hole, 20mm length PCB spacer posts
magpi.cc/2dvjKJR

12× 3mm, 8mm length hex pan head machine screws
magpi.cc/2ebkaWQ

8× straight header pins for motors
magpi.cc/2eeUbv9

Optional camera:

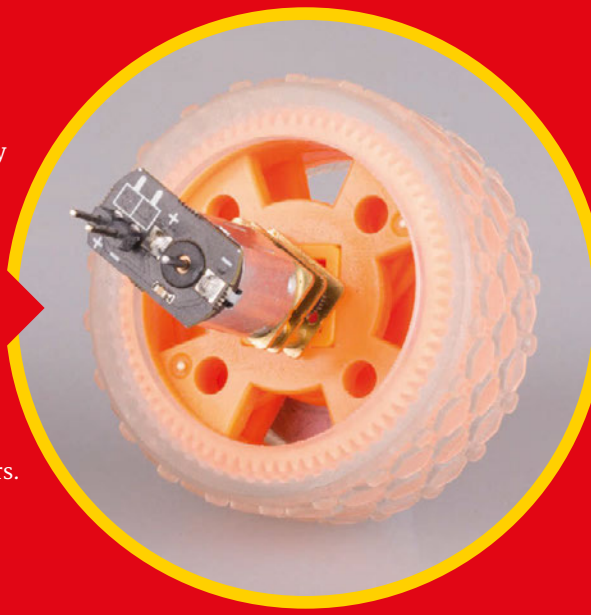
Camera holder

Raspberry Pi Camera Module

>STEP-01

Prepare the motors

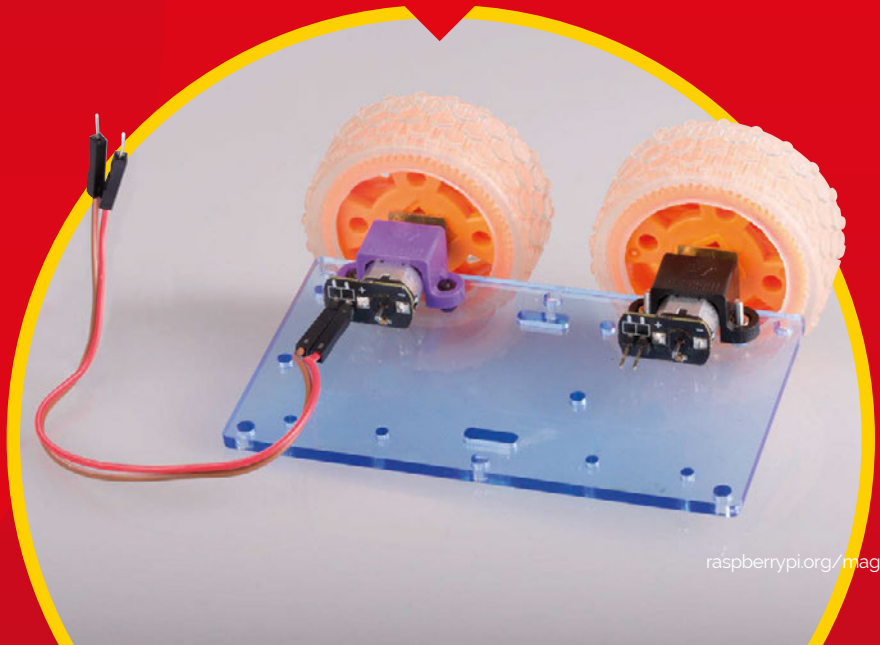
The motors must be modified slightly to make sure they fit under the chassis. Using a soldering iron and a pair of pliers, you should remove the bent pins from each motor shim, suck out the solder, and solder some straight pins back in. Once that's done, connect the wheels to the motors.



>STEP-02

Attach the motors

The motors need to be attached to the bottom plate using the brackets, as shown. You can either have the wires connected now while it's easier to do, or you can add them afterwards so they're out of the way as you connect the rest of the motors.



>STEP-03

Tidy the wires

Once all the motors are connected, flip the bottom plate the right way up and make sure all the wires are connected to the motors. You can push them two at a time through the rectangular holes on the side, which you'll need to do now.

>STEP-04

A little bit of soldering

Solder the header for the ZeroBorg onto the Pi Zero. It should be positioned on pins one through six, as shown above. Make sure it's soldered to the underside as in the picture as well!

>STEP-05

Make the brains

Attach the spacers to the ZeroBorg and then follow that up by placing the Pi Zero on top, making sure the header goes over the relevant pins. The USB ports and HDMI port are on the same side as the ZeroBorg connectors – refer to the step 06 image, just in case.

>STEP-06

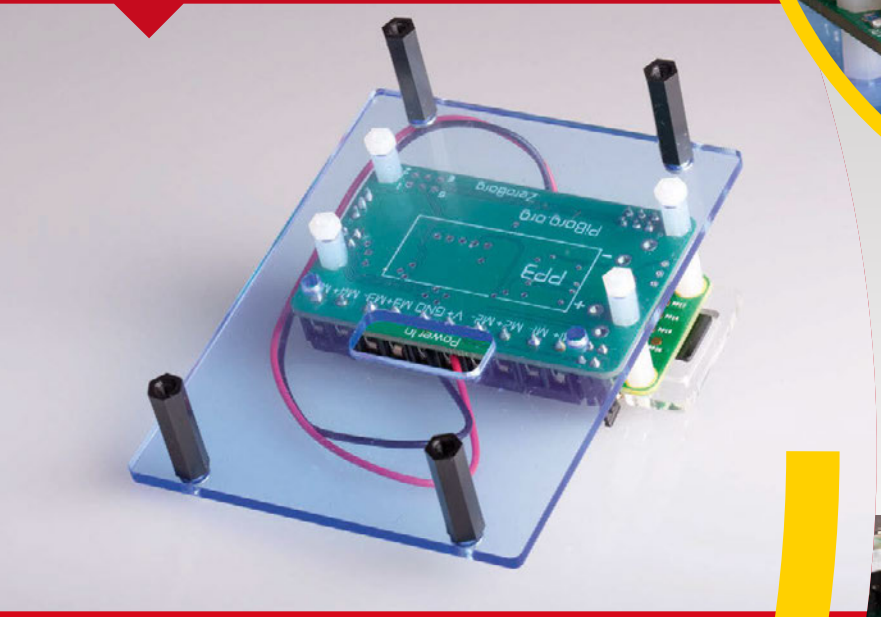
Construct the top part

You can attach the power wires now if you wish – refer to step 09 for the orientation – but either way, you need to then mount the ZeroBorg and Pi Zero combo to the top plate. It attaches to the shorter side; you'll know as it's the only spot you can slot in the screws.

>STEP-07

Complete the top

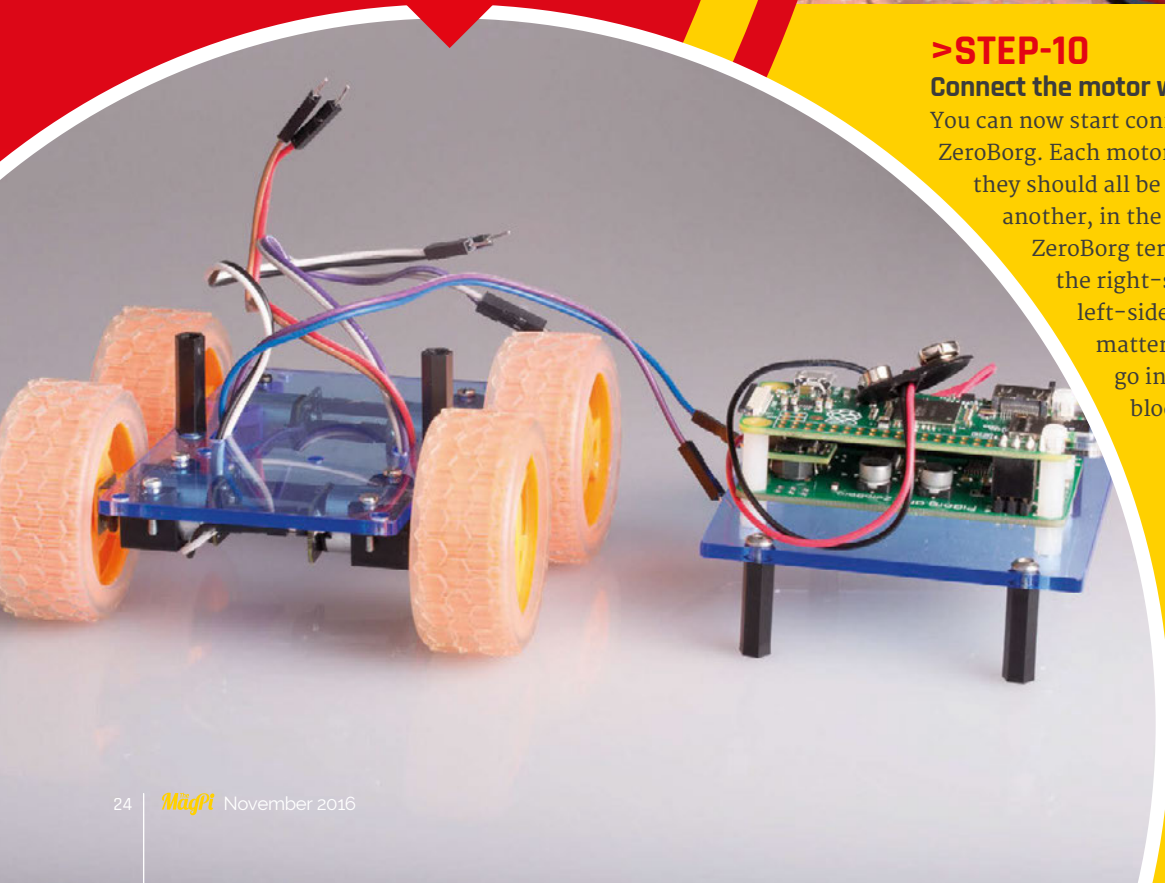
Once the Pi Zero combo is attached, attach four of the spacers for connecting the two plates onto the bottom of the top plate, as shown below.

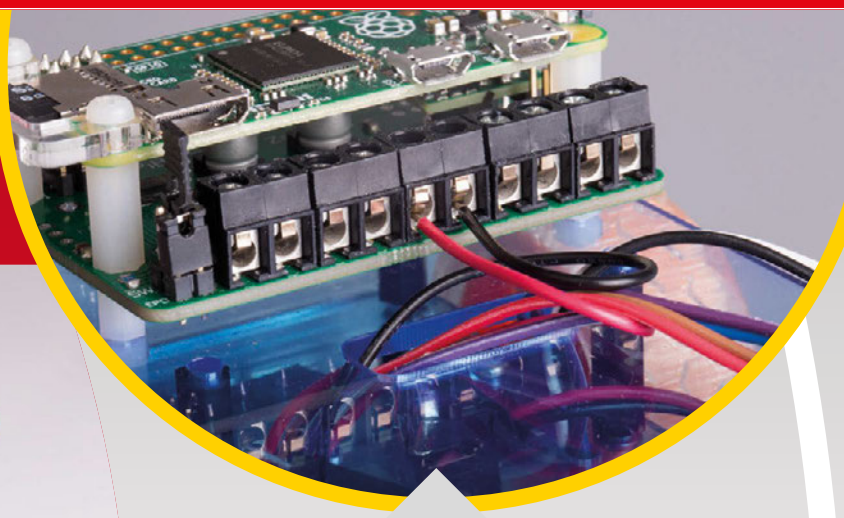


>STEP-08

Build up the robot

Attach the remaining two spacers onto the bottom plate; these can be secured to the top plate by removing the Pi Zero combo, but it's not necessary. Place the top plate onto the chassis and secure the top plate's spacers to the bottom plate.

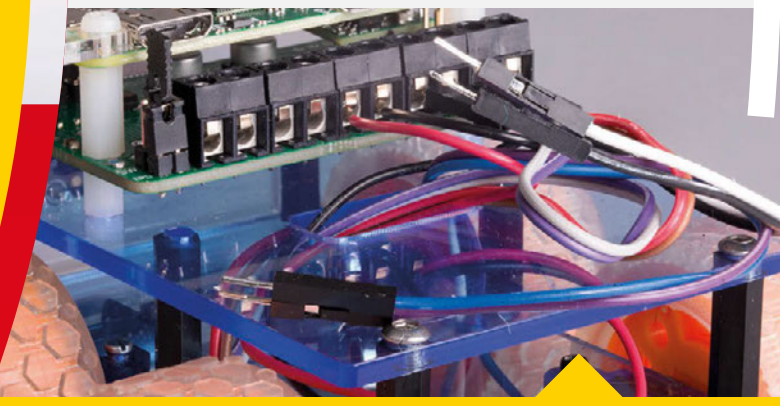




>STEP-09

Check the battery wires

If you haven't already, connect the power wires to the central terminals, as shown. It's important to do so in this order (positive on left, negative on right), otherwise you won't be able to properly power the ZeroBorg, which in turn powers everything else.



>STEP-10

Connect the motor wires

You can now start connecting the motors to the ZeroBorg. Each motor has a pair of cables, and they should all be connected in pairs, one after another, in the remaining four pairs of ZeroBorg terminals. It's a good idea to keep the right-side motors on the right and left-side on the left as well. It doesn't matter which way around the pairs go in their individual terminal blocks, though.

>STEP-11

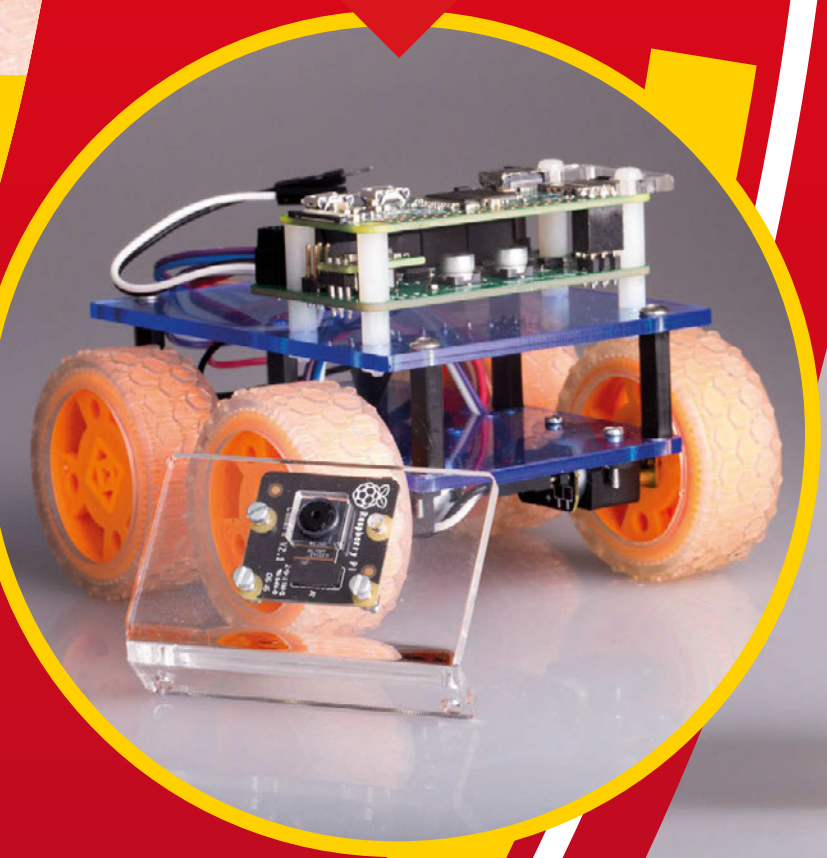
Tidy the robot up

Tidy up the wires and connect the battery; it won't turn the robot on until you move the jumper to the on position. Connect the wireless controller's dongle and you're ready to get programming, if all you want is a remote-controlled robot.

>STEP-12

Mount the camera

To add the camera, screw the Camera Module to the extra camera plate. This can then be mounted to the front of the bottom plate, removing the screws that secure the spacers and using them to add the camera.



>STEP-13

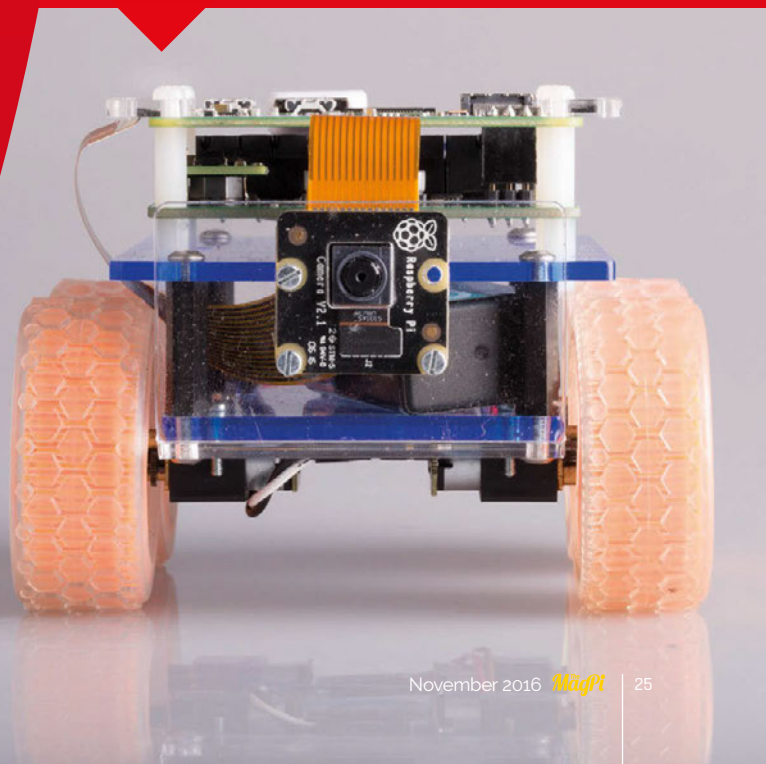
Connect the camera cable

The last thing to do is add the camera connector; it needs to go in both the Pi Zero (v1.3) and the Camera Module. Make sure the white side of the cable is facing up when you connect it to the Pi Zero, while the silver side should be facing the Pi Camera when it's inserted in that end.

>STEP-14

Robot complete!

You're finished! Now, with a bit of coding, you can get your robot working. We'll get started over the page...



PROGRAM YOUR ROBOT

It has a body. Now it's time give it a brain!

As we're using the ZeroBorg, we will use the library that comes with it to program the robot. We'll need to modify the code slightly to get it working for our needs, though. It's best to start with a fresh install of Raspbian as well – you can do the setup on another Raspberry Pi if you wish.

Start by downloading the latest edition of Raspbian or NOOBS and copying it to a microSD card. There's a quick-start guide to doing so on the Raspberry Pi website (**magpi.cc/2eopaEf**), so you can either follow the instructions given there or read our guide from issue 50 (**magpi.cc/Issue-50**).

>STEP-01

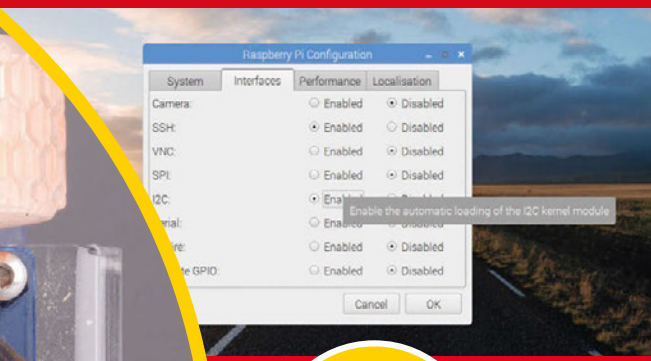
Update Raspbian

Once installed, connect your Raspberry Pi to the internet and update it in a terminal window or the command line with:

```
sudo apt-get update
sudo apt-get upgrade
```

Next, enable the I²C bus. You will need to do this via the Raspberry Pi Configuration menu. Click the Menu button at the top left of the Raspbian desktop, select Preferences, and finally, click Raspberry Pi Configuration. Find the Interfaces tab and then click the Enable button for I2C. Click the OK button to save and exit, then restart your Raspberry Pi.

It's best to test the motors with the robot upside down or in the air so it doesn't go running off



Enabling I²C here is extremely important for making sure the robot works

>STEP-02
Install ZeroBorg software

Now you need to download the ZeroBorg software. Open a terminal window and enter the following:

```
bash <(curl https://www.piborg.org/
install-zeroborg.txt)
```

You should also install the joystick app for testing your joypad and mapping the buttons. See the 'Using a gamepad' section (bottom right) for more details.

The button mapping for the game controller is in **zbJoystick.py**. Use nano to open the file, and find the line `# Settings for the joystick`. For the Rock Candy controllers used in our version, it should look something like this:

```
axisUpDown = 1
axisUpDownInverted = False
axisLeftRight = 2
axisLeftRightInverted = False
buttonResetEpo = 9
buttonSlow = 6
slowFactor = 0.5
buttonFastTurn = 7
interval = 0.00
```

>STEP-03
Auto-start on boot

The final step is for the software to auto-start when you power on your robot. On the command-line or in a terminal window, use:

```
sudo nano /etc/rc.local
```

This will open the nano text editor; after the line starting with `fi`, enter the following:

```
./home/pi/zeroborg/runJoystick.sh &
```

Save and exit. You can now test your robot! If you have not done so already, put the microSD card into the Raspberry Pi Zero, then power up your robot by moving the jumper on the ZeroBorg to cover both the power pins. Test the motors by pushing forward on the wireless controller's left stick; this should result in all four wheels moving in the same direction.

If some wheels are going in a different direction, swap around their cables in the ZeroBorg for that specific motor. Next, push the stick to the left and right, making sure that the correct wheels run when selected – if they do not, swap the incorrect pairs of jumpers.

CONTROL FROM A WEB BROWSER

Control your robot from your computer or smartphone and use the on board camera

For this way of controlling the robot, you'll have to switch out any game controller receiver for a WiFi adapter. Plug the Pi Zero into a computer and get the WiFi connected before continuing.

Once that's done, you need to find the IP address of the robot by opening a terminal window and using:

```
ifconfig
```

Make a note of it – this is how we'll connect to the robot from elsewhere. Then install OpenCV using:

```
sudo app-get install python-opencv
```

Once that's done, you'll need to download the PiBorg web interface. Back in the terminal window, use:

```
git clone https://github.com/piborg/diddyborg-web.git
```

This will create a folder called **diddyborg-web**. Enter the following commands to start the web server:

```
cd diddyborg-web
sudo python diddyborg-webyetiWeb.py
```

It will confirm when the web server has started. Type the IP address you found earlier into a browser on your PC or smartphone (or even another Raspberry Pi!) and you'll be able to connect to the robot and see through the camera. Disconnect the monitor and any peripherals, then go for a ride!

USING A GAMEPAD

To get the gamepad or joystick button numbers, install the joystick software with:

```
sudo apt-get install joystick
```

Plug your gamepad in and then run the following to find out how it's listed:

```
ls /dev/input/js*
```

It will probably come up as something like /dev/input/js0. You can then test it using:

```
jstest /dev/input/js0
```

Move each stick and press each button in turn. You will see the values change for the axis or button pressed in real-time. Make some notes so you remember which button is which!

NEXT ISSUE: THE CHALLENGES

Come back next issue to learn how to add and use sensors to your robot to make it a true automaton

Pi Wars is next April and has a load of different challenges; it's a bit too late to enter them, but that doesn't stop you from learning how to get your robot competition-ready by using some excellent robo-sensors. Come back next month for our guide on how to add and use amazing sensors to conquer these challenges.

STRAIGHT-LINE SPEED TEST

The Straight-Line Speed Test is autonomous, with only a start and stop button allowed for the starting and stopping of your robot's run. The course is a straight run, just over 7.3m long, with walls 67mm high placed 522mm apart – very precisely. There are penalties if your robot touches a wall, plus points for each clean and completed run. Three runs must be attempted. Here are some methods you could use for this challenge...

Computer vision: Find the walls and guide your robot down the centre. You could also use an IR light beacon placed at the end of the course and aim to keep the beacon in the centre of the image, while steering the robot down the centre of the course.

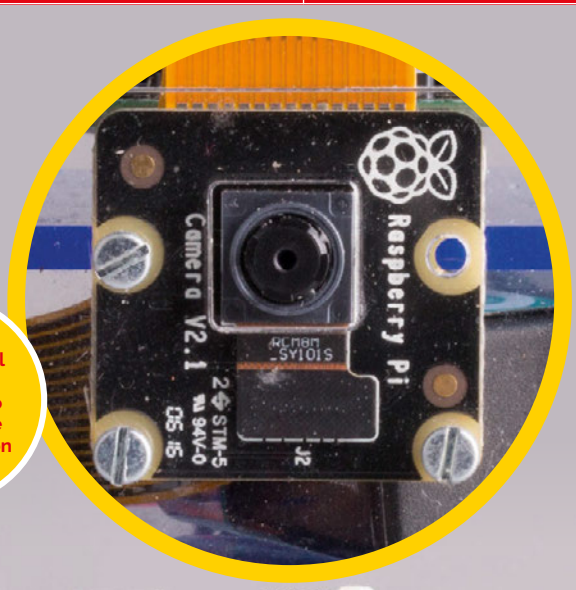
Dead reckoning using wheel/motor encoders: Count the number of turns each wheel makes in a set time. The shorter the time, the more accurate it should be.

Distance sensors: Measuring the distance between the walls, steer the robot down the centre of the course.

IMU: Set a bearing and follow it – distance sensors may be useful as a backup check.

This ultrasonic distance sensor can be used to check how far away the wall is

MINIMAL MAZE



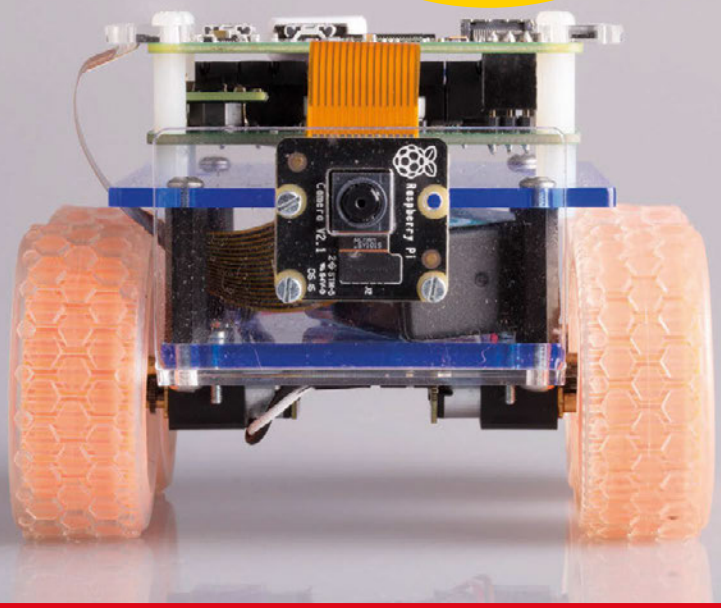
Check the wall colours with the camera to determine the robot's direction

The Minimal Maze is new to the Pi Wars contest, and it is an autonomous event. It's basically two right turns followed by two left turns in a course with 65mm-high walls. Additional points will be given for clean runs where the robot does not touch the walls, along with points for a completed run.

Penalties are given for touching walls, rescue attempts, and non-completed runs. As the measurements for the maze are not given, it will not be possible to use dead reckoning to navigate the maze, so the challenge requires the use of sensors. Not counting access to a lidar (a laser radar!), we have a number of sensors at our disposal.

You could use the Pi Camera Module and OpenCV to find the positions of the walls or determine their colour. The walls are colour-coded to their orientation, so you will be able to tell which way your robot is facing.

It may be a good idea to use distance sensors to avoid hitting the walls. Another method would to drive forward until you are a set distance away from the wall, then turn 90 degrees, either clockwise or anticlockwise depending on whether you need to turn left or right, repeat until last turn, then drive forward to the exit. The use of wheel/motor encoders and an IMU may help. If you use the data from your first run, it may be possible to improve your next run's time.



Line followers come in many varieties: choose the best one for the size and shape of your robot

LINE FOLLOWING

The classic line-following challenge returns to Pi Wars. This time, organisers Michael and Tim have promised a return to the black line on a white background for the course. You have a number of options, including building your own line-following sensor, or buying one of the many available sensor arrays. A popular choice is Ryanteck's three-way line follower (**magpi.cc/2eoEXTI**), as used by the winning robot for the line-following challenge in 2015. Other sensors are available from Pololu and Sparkfun. The line-following sensor used by Revenge, the second-place robot in the last contest, was a Pololu QTR interfaced with an Arduino.

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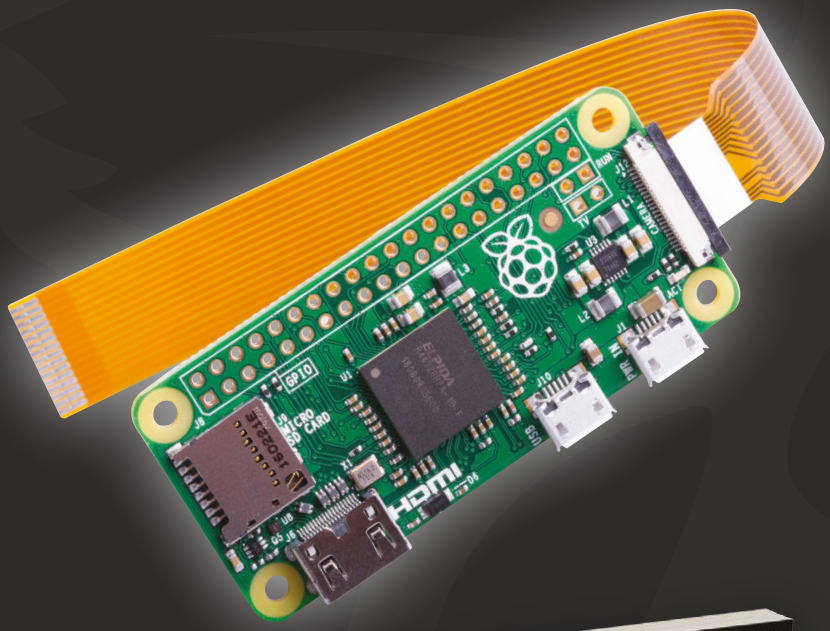

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BETHANIE FENTIMAN

19-year-old Bethanie plans to visit every Disney park in the world… which is an amazing bucket list goal if ever we've seen one.
magpi.cc/2cnzMDO

Sadly, the pieces have yet to crush their opponents, as they do in the book
Etched acrylic allows magnets to move the pieces from beneath
Motors on an x- and y-axis select the appropriate piece to move

WIZARD CHESS

Quick Facts

- Watch the set in action at **youtu.be/Z7xdFn5bVrA**
- The Wizard Chess Tour started in Harlow
- After Harlow, it visited the Covent Garden Raspberry Jam
- Inspiration came from Instructables user maxjus at **magpi.cc/2cnyoBo**
- It's wingardium leviOsa, not leviosAH

19-year-old Bethanie Fentiman shocked her A-level classmates when she rocked up with a fully working Harry Potter Wizard's Chess set as her final coursework assignment

Bethanie Fentiman can't play chess, but when her imagination sparked and the opportunity presented itself, she brought the iconic game of Wizard's Chess from Harry Potter to life using a Raspberry Pi, stepper motors, and possibly a little magic.

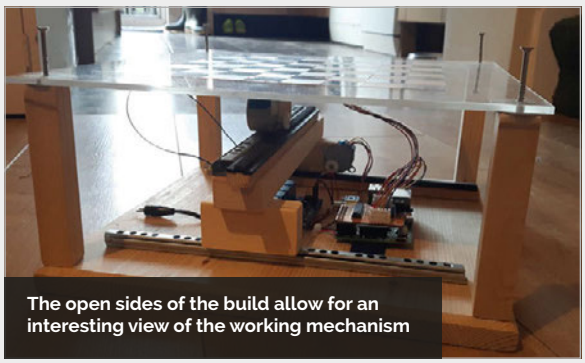
For her A-level computing coursework, Bethanie took an idea that had been nestling in the back of her mind, and turned it into a reality. Well, as much of a reality one can create when the literary version includes battling chess pieces that leave their opponents crushed to rubble on the board.

Luckily for Bethanie, she's a self-proclaimed Jambassador, actively participating in the Raspberry Pi scene via the Kent Raspberry Jam. With a community of makers to support her, Bethanie knew that she could complete the build and got to work, researching similar projects online that used magnets and motors to 'magically' move chess pieces on a board.

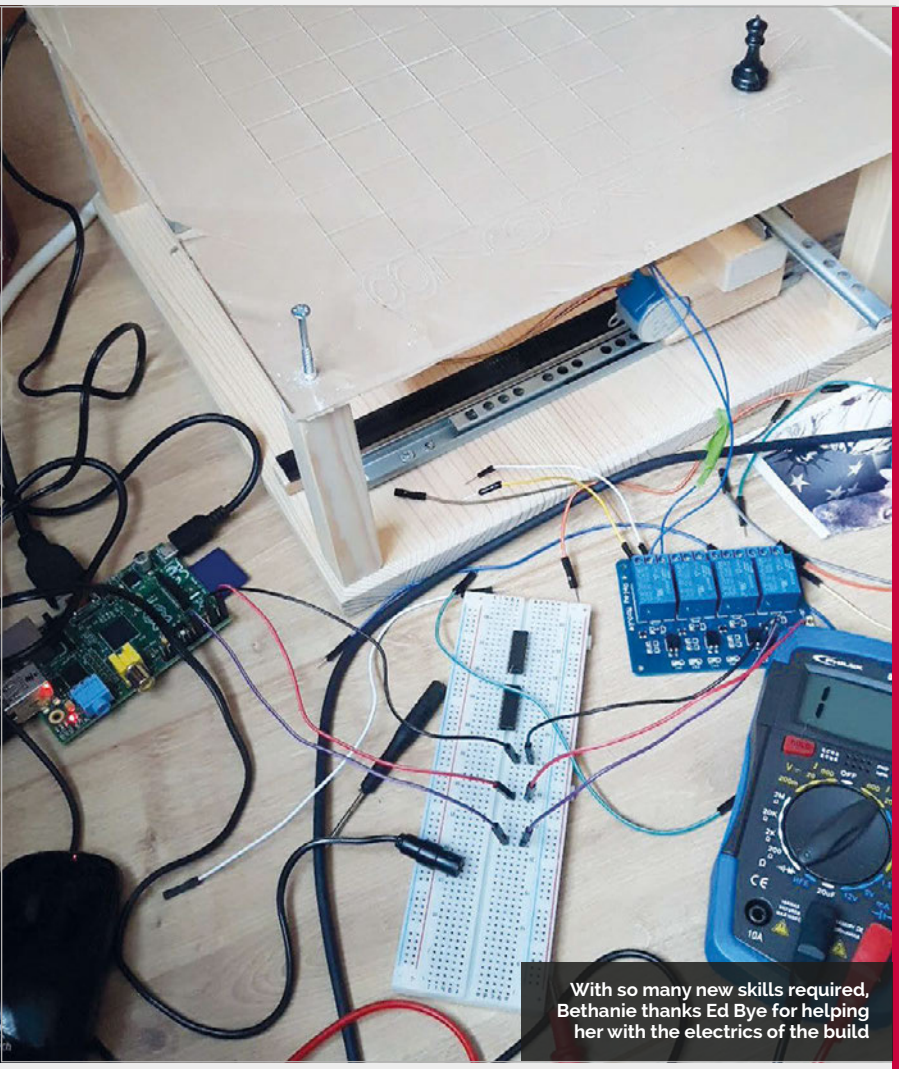
After an internet search for inspiration, she came across an Instructables build for an Arduino-powered chess-playing robot by user maxjus, and used the main concept as the basis for her build. The guide provided all the information Bethanie needed to build the physical structure of the board, allowing for drawer runners, gears and, of course, the electromagnet that would move each piece when required. A 4tronix PiStep board, along with two 28BYJ-48 stepper motors, took up the job of moving the runners and electromagnet into place, linked through to the Raspberry Pi.

As mentioned previously, Bethanie didn't actually know how to play chess. So when it came to inputting the legal movements of each piece, she had two options: learn fast, or cheat a bit. Opting for the latter due to the time constraints of her coursework deadlines, Bethanie researched all the possible moves of each chess piece and worked them into the code. She could always learn to play the game later on.

A second issue, and one far more associated with the original material from which she was taking her inspiration, was what



The open sides of the build allow for an interesting view of the working mechanism



With so many new skills required, Bethanie thanks Ed Bye for helping her with the electrics of the build

> "When I turned up with the fully moving and playable board at school, they were shocked"

the pieces would do as they 'took' an opponent. In the book, each piece defeats its foes through 'barbaric' means. In reality, Bethanie plans on an upgrade to allow for movement around pieces… though once she gets her belated invitation to Hogwarts, we're sure she'll incorporate the expected level of brutality.

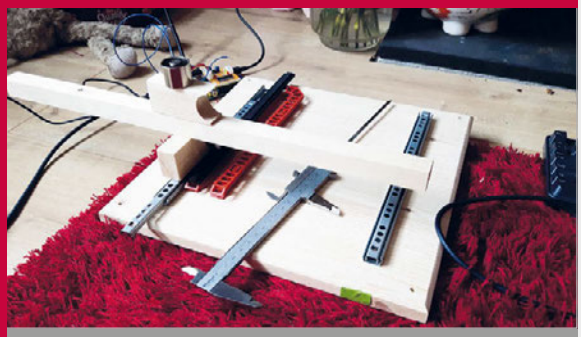
With the build complete and presented to her computing A-level class, Bethanie's Wizard Chess was met with amazement.

"When I said I was going to make it, they just thought I was going to write the code and come up with designs for the board. So when I turned up with the board at school, fully moving and playable, they were slightly shocked."

And they weren't the only ones. Upon finishing her board, Bethanie took it to the Kent Raspberry Jam, where Twitter soon exploded with praise. From the Jam, 'The Wizard Chess Tour' was born as Bethany and fellow Jam members took to the road and presented the project at Jams in both Harlow and Covent Garden.

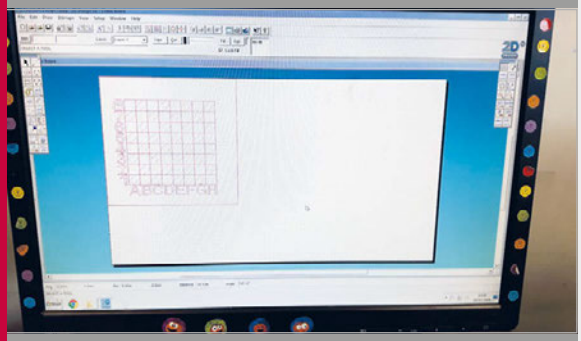
Now actively seeking an apprentice in the field, Bethanie plans on upgrading the build while continuing the Wizard Chess Tour at more Jams in the future.

YOU'RE A (CHESS) WIZARD, HARRY



>STEP-01
Setting up the runners

Runners allow for the motors to move the electromagnet, and code dictates which pieces to shift across the board. Here Bethanie could put her newly discovered soldering skills to the test.



>STEP-02
Etching the acrylic

Bethanie was fortunate enough to have access to various pieces of equipment, although she admits that any future build would omit the added vinyl that made movement less fluid.

>STEP-03
Building the board

The entire build was a learning curve for Bethanie, allowing her to expand her knowledge of new skills and to call on a number of Raspberry Pi community members for support.

JOON GUILLEN

When not busy being a dad, Joon works for an online retailer as a Linux sysadmin. And when not busy doing that, he makes music under the moniker modulogeek and dabbles in geeky projects from time to time.
modulogeek.com

MONOMEPI

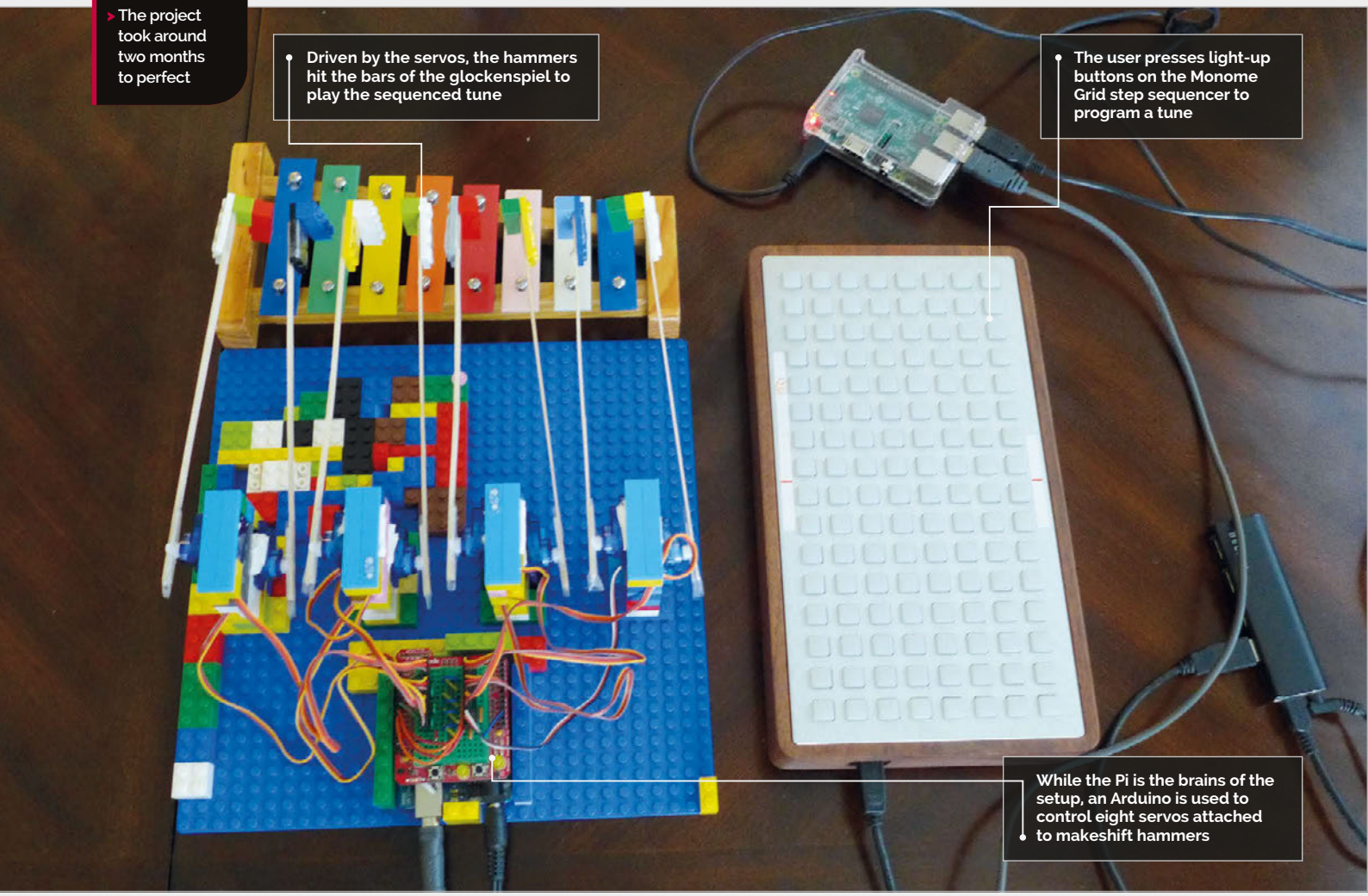
A music box featuring old and new technology in perfect harmony

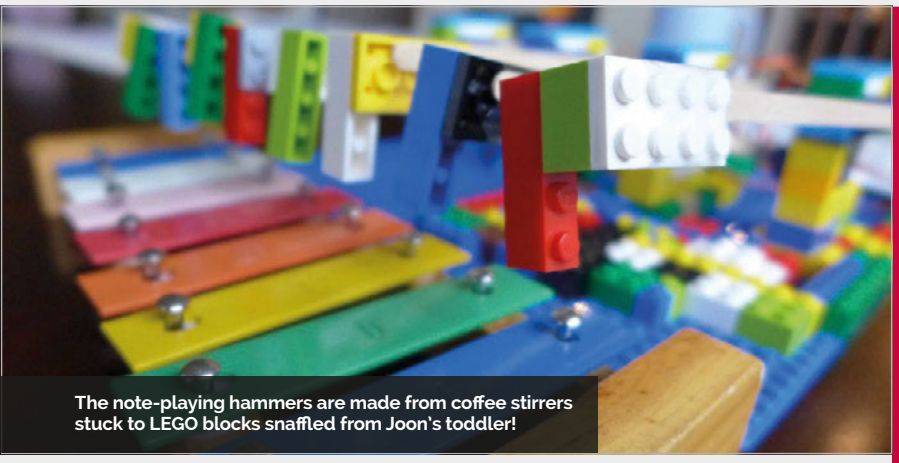
Quick Facts

- The LEGO contraption took around three evenings to build
- Joon's young daughter added some extra blocks
- The hammers are made from coffee stirrers and LEGO
- A Pi 3 runs the Python sequencing software
- The project took around two months to perfect

With hammers hitting the bars of a toy glockenspiel to play a tune, the Monomepi sounds just like an old-fashioned music box, but this Pi-powered contraption is based on new technology… and on quite a lot of LEGO. "It was just my luck that the components fitted with the LEGO bricks almost perfectly!" reveals its creator, Joon Guillen.

He got the idea after seeing a couple of videos of Arduino-based music boxes a few years ago, while working on a Conway's Game of Life Pi project using a Monome Grid, a versatile piece of hardware that can be used to control music and more. For the Monomepi, the Monome is connected to a Raspberry Pi 3 running a step sequencer program, which registers the user's button presses on the Monome and lights them up accordingly. The Pi then sends serial commands to an Arduino Uno connected via a ProtoShield kit to eight servo motors, which move makeshift hammers to play glockenspiel notes to match the pattern shown on the Monome. On the latter, the user can switch buttons on and off to alter the sequence as it plays.


Driven by the servos, the hammers hit the bars of the glockenspiel to play the sequenced tune
The user presses light-up buttons on the Monome Grid step sequencer to program a tune
While the Pi is the brains of the setup, an Arduino is used to control eight servos attached to makeshift hammers



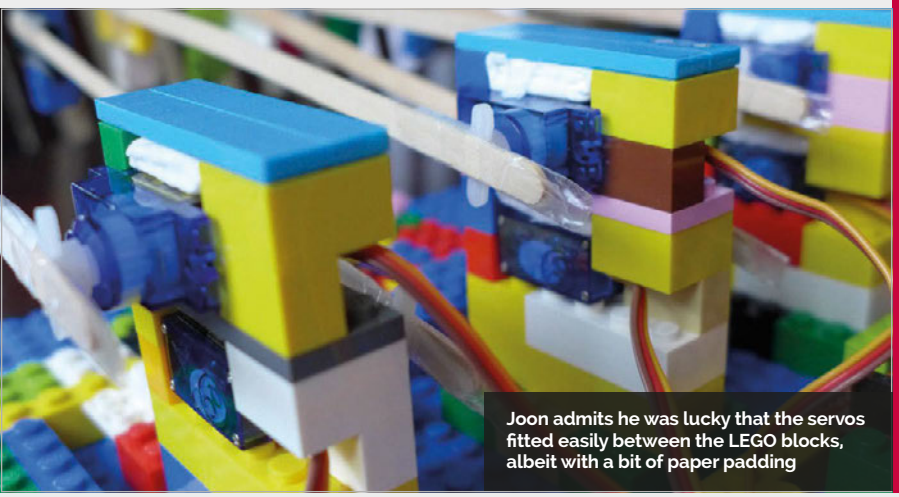
The note-playing hammers are made from coffee stirrers stuck to LEGO blocks snaffled from Joon's toddler!

"The contraption itself took only two or three evenings to build," Joon tells us. "I focused most of my energy on the software side, so the physical construction was almost an afterthought." To build it, he borrowed a bunch of LEGO blocks from his young daughter. "They were the first things I thought of using. I haven't the talent for crafts, and so LEGO was the quickest way to build the contraption. My daughter even added some blocks of her own in there!"

While the construction was quick, the project as a whole took around two months, with Joon working casually over the course of several evenings and weekends. "Most of it was figuring out the step sequencer logic, Arduino code, and optimising performance." The main Python program running on the Pi is based on a Monome library Joon had created for his previous project. "That took a very long time, as I had zero Python knowledge when I started out. The library has since undergone several improvements through the years."

While Joon opted to control his servos via an Arduino, he says there's no reason why anyone creating a similar project couldn't trigger them from the Pi itself, using a suitable motor driver board. And if you're lacking a Monome (quite an expensive piece of kit), a touchscreen could be used instead: "A web-based UI should work, too. Or, if one isn't necessarily trying to make a step sequencer, push buttons or [a computer] keyboard are viable control alternatives."

As a part-time musician, Joon plans to sample the Monomepi to use in at least one of his tracks. He's also looking to improve the project by "adding features to the step sequencer program, such as having more than 16 steps, and the ability to use multiple velocities. Other than that, I am trying to think of more ways to use my servos with the Pi!"



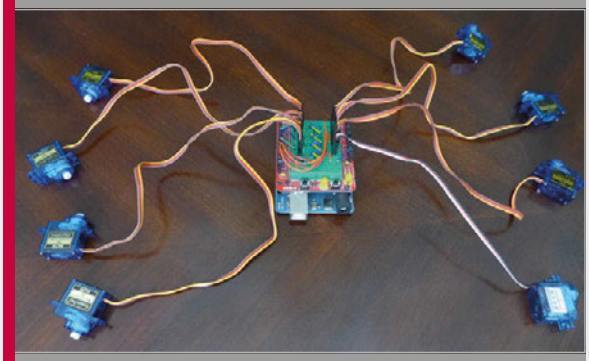
Joon admits he was lucky that the servos fitted easily between the LEGO blocks, albeit with a bit of paper padding

BUILDING A MODERN-DAY MUSIC BOX

>STEP-01

Glockenspiel hammers

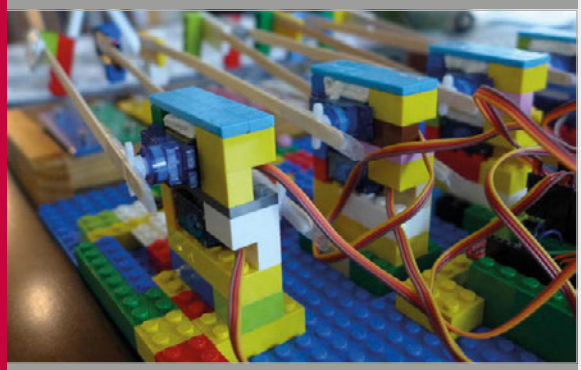
To play the notes on a toy glockenspiel, the hammers are made from coffee stirrers, sticky tape, and LEGO blocks borrowed from Joon's young daughter.



>STEP-02

Arduino servos

Eight servo motors are connected to an Arduino Uno R3 and ProtoShield kit with a mini-breadboard. This is controlled by the Raspberry Pi and Monome Grid.



>STEP-03

LEGO construction

With the wiring complete, it's time to connect the hammers and add more LEGO blocks around the servos to keep everything firmly in place.

LLOYD BAYLEY

Lloyd is an IT consultant/systems engineer and maker. He's played the piano since he was a child and taught himself to play by ear.
bayleysbanter.com

YAMAHA
The touchscreen display enables users to control the Raspberry Pi and select MIDI tracks
The MIDI file is used by the pianola to determine which keys to play
A USB-to-MIDI cable is used to connect the Raspberry Pi to the Yamaha Disklavier's MIDI IN socket

Quick Facts

- Pianolas were first developed in the late 19th and early 20th centuries
- Original pianolas used bellows to push down keys with air
- The keys in this pianola are pushed using electromagnets
- It can play songs backwards
- Lloyd originally used aplaymidi from the command line

PIANOLA

When one maker's self-playing piano failed, he used a Raspberry Pi to repair it... and made it his pianola play even better than before

"I've always wanted an pianola," says Lloyd Bayley, the owner of this rather fantastic Yamaha Disklavier self-playing piano.

Pianolas may look like regular instruments, but they don't just make the sound of a piano. They also move the keys all by themselves.

Self-playing pianos have a long and distinguished history. "I was around the old paper roll, bellows-driven ones when I was a child," Lloyd reminisces, "and I found them fascinating. I found this one at a Sydney piano shop and went to visit them for a demonstration and decided to buy it on the spot... I'm still enjoying it after almost three years."

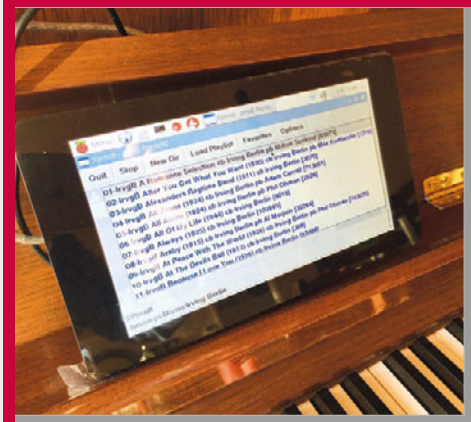
Pianolas are spectacular to watch. Classic versions were controlled by reams of paper with holes punched into them. You can see self-playing pianos in classic movies (particularly westerns and comedies). Modern pianolas have replaced the paper rolls with floppy disks and MIDI files.

"The piano itself doesn't store songs," explains Lloyd, "as it has no on-board memory. Everything must be loaded via floppy drive or via the MIDI ports."

The electronic system uses programming to fire solenoids, "which are a bit like a little finger that prods the hammers to strike the strings," says Lloyd. "The strike force can be varied, and they are thus able to play loud and soft notes with ease."

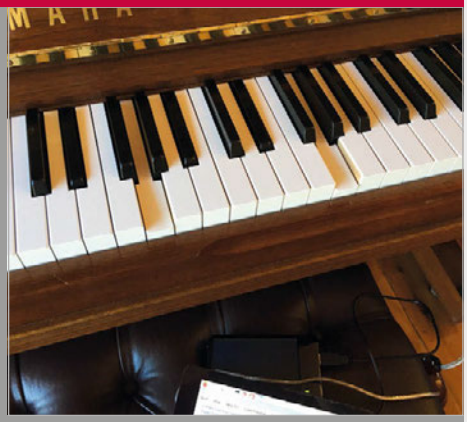
Lloyd's Yamaha Disklavier eventually suffered a hardware fault. The 3.5-inch floppy drive, which was used to load the music files, stopped working. Rather than pay for an expensive replacement from Yamaha, he chose to use a Raspberry Pi with a touchscreen display instead.

CONTROLLING A PIANOLA



>STEP-01
Touchscreen
A touchscreen display with a Raspberry Pi mounted on the rear is used to control the pianola. It is loaded with XPMIDI, which provides an interface to select, and then play, the MIDI tracks.

>STEP-02
MIDI input
The Raspberry Pi connects to the pianola via the MIDI IN connector (using a USB-to-MIDI converter cable). MIDI files contain information on which notes to play, and MIDI is used to start and stop playing tracks.



>STEP-03
Tapping the keys
The MIDI file sent by the Raspberry Pi controls the Yamaha Disklavier directly. The signals are used to activate solenoids, a type of electromagnet, inside the piano. These push the keys down, and the piano plays itself.

The Raspberry Pi attaches to the back of the touchscreen with pre-installed mounting accessories. "To connect it to the pianola, I used a USB-to-MIDI converter cable and was a little surprised to find it was that simple."

Lloyd loaded the Raspbian Jessie operating system and tried to play a file on the command line with the aplaymidi utility. "I was going to write my own cataloguing and playing software and while researching it, I came across XPMIDI (**magpi.cc/2cCfG9L**), which does the job nicely. It has a GNU public licence, so you can modify it if need be."

> "It was quite an easy project, as most of the 'trickery' is already in place"

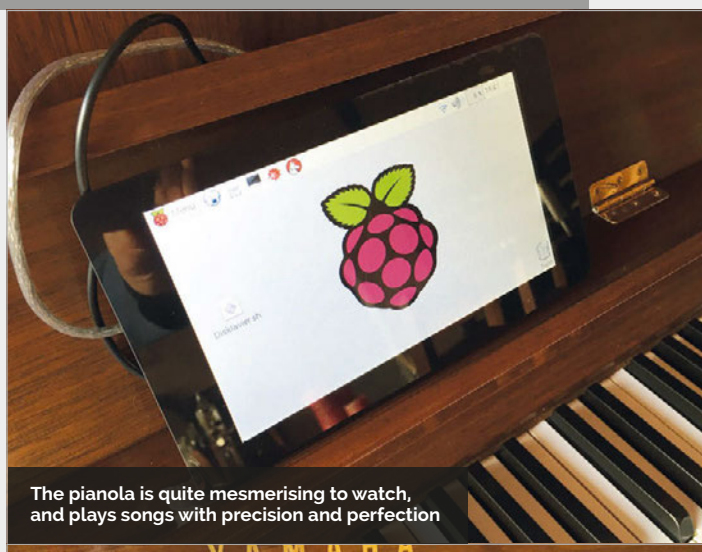
The end result is a fully working, self-playing piano which is a vast improvement upon the original version. Lloyd is able to store far more songs, and a program that he developed for the touchscreen enables rapid access to his choice of a list of thousands of songs.

"It's working and working well," says Lloyd. "I have a few different playlists that I favour, and I also like to play manually as well. It's a nice happy pianola to have around the house.

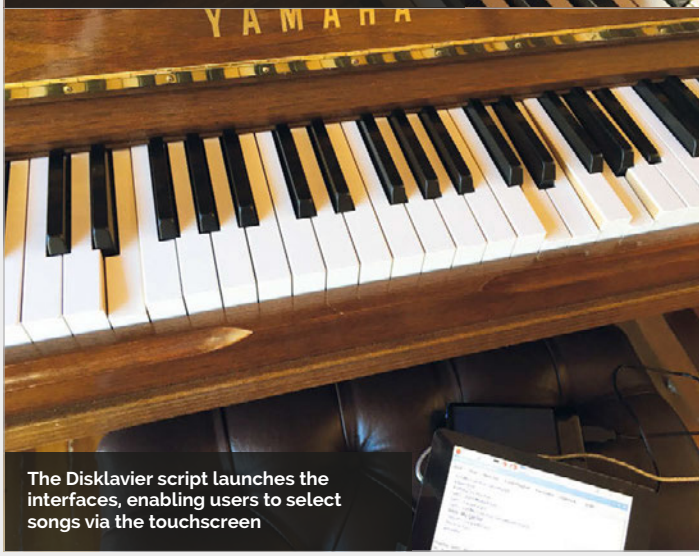
"I have showed it to people and they are amazed, and think I'm very clever. However, it was quite an easy project, as most of the 'trickery' is already in place. I just had to fit all the pieces of the puzzle together."

Lloyd tells us that his pianola project is mostly complete. "I think I would like to have a crack at doing the reverse, so I could play straight into the storage on the Raspberry Pi." This is a feature built into the pianola, but it writes directly to the floppy disk.

"With a bit of extra software," says Lloyd, "you could output through the MIDI ports back in. That will take a little research and is on the list of things to do."



The pianola is quite mesmerising to watch, and plays songs with precision and perfection



The Disklavier script launches the interfaces, enabling users to select songs via the touchscreen

TEEFAX

PETER KWAN

Having worked as an engineer with teletext equipment for the last 12 years it was transmitted in the UK, Peter is an expert in the field. When not recreating teletext, he's out riding his bike through the valleys of Stroud.

teastop.co.uk/teletext

Teletext makes a comeback with the help of the Raspberry Pi

Quick Facts

- Peter built a text service for the Stroud Fringe festival
- New Teefax contributors are always welcome
- You can use Peter's wxTED page editor **(magpi.cc/2dsEZfG)**
- Dave Honess has made a teletext QR code generator
- Peter is developing a Muttlee multi-user live editing system

Before the dawn of the world wide web, teletext was the best way of keeping up to date with the latest news, sports scores and other information. The BBC's Ceefax teletext service continued in the UK right up until analogue TV transmissions ceased in October 2012. We still miss its no-nonsense approach and blocky graphics, so we're delighted that teletext has been revived by the Teefax project. Users can install the free software (**magpi.cc/2dssVeo**) on a Raspberry Pi, connect its 3.5mm video output to a TV (via the SCART socket), then hit the teletext button on the remote control.

Project founder Peter Kwan is a former teletext engineer who carried on working in the field as a hobby. "As the analogue TV network was being shut down, I was thinking about how I could generate my own teletext," he recalls. With the idea of making a low-cost basic teletext inserter, Peter manufactured his own VBIT hardware and managed to get a full teletext service running on it. Initially, there was a practical use for the system. "There is a lot of hidden signalling in the teletext signal," Peter reveals. "The BBC uses a system called Presfax which hides schedule information in databroadcast packets. They also have special signals that let London take over the whole

Teefax project founder Peter Kwan is a former teletext engineer
To control the service, just use the teletext buttons on your TV remote, as usual
The data transmitted via the Pi's composite video signal is converted into teletext pages
100 Teefax 100 Fri 12 Aug 07:39/11
TEEFAX
News
TEXT TESTCARDS TEEFAX TIME TUNNEL P506
CARLOS.... 777&501 STROUD BAMBOOZLE 152
TEEFAX BBS.... 503 TESTCARDS INDEX. 506
BBS HOW TO.... 502 UKEFAX..... 600
Chris.T..... 540 CY2..... 530
BBC NEWS..... 104 MR BIFFO..... 518
TWITFAX..... 153 Ant nest map.... 899
BenFA..... 560
JOKETITLES.... 888 OREGON TRAIL.... 551
REMEMBER TO ./updatepages.sh in SSH

P519 0001 0002 0003 ▶ S0001
VBIT-PI 519 Wed 05 Oct 11:50/13
YOUR HOUSE... WHO YOU GONNA CALL?
HAIREATERS!
Hair... it is modern problem. Hair here, hair there - hair everywhere. But hold! For now there is solution to excess of domestic hair... HAIREATERS!
OYEZ! OYEZ! OUR HAIR-EATING SPECIALISTS WILL VISIT YOUR HOME AND EAT HAIR FROM THE FOLLOWING PLACES: * Your hand/plate * Bath hole * Rear of husband * Cat's stomach * Sofa * Dofa? * Other holes MUNCHMUNCHMUNCHMUNCHMUNCHMUNCHMUNCH!
YOUR HOME WILL BE 100% FREE OF UNWANTED HAIR, WHISKERS AND TUFTS! YES! YES!
DISCLAIMER: Our hair-eating specialists really like eating hair, but we cannot be held responsible for anything else they might do. They're a bit funny in the head, and one of them once did a big blow off in a customers's mouth.

Above Along with news, Teefax pages include teletext art, quizzes, and some humorous articles from the likes of Mr Biffo

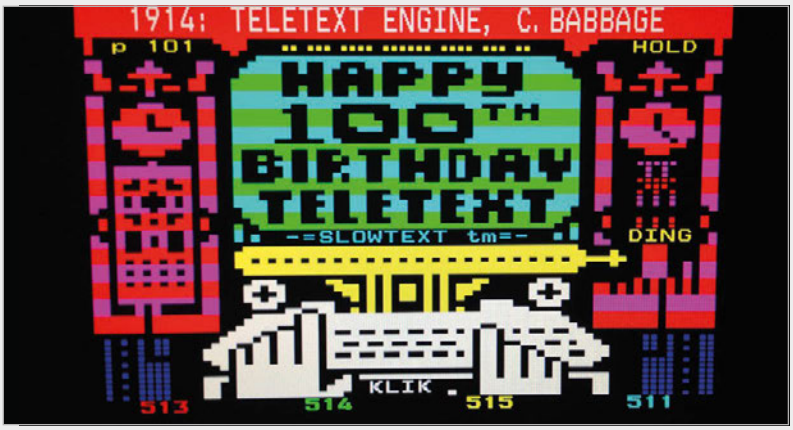
network in an emergency." In addition, betting chains use control signals to switch TV channels or mute audio in their shops, while European broadcasters use opt-out signals to insert local adverts. "These all need testing and VBIT was a low-cost and flexible way of generating these signals."

When the Raspberry Pi was launched in 2012, Peter soon realised it could be used instead of his bespoke hardware. "It had I²C, SPI, and GPIOs to drive and it was cheaper than the AVR boards that I was using, so I hooked one up and it worked. I made a second spin of the board and called it VBIT-Pi."

The next big breakthrough came when Alistair Buxton managed to create a teletext signal direct from the video output of the Pi. "I bypassed the teletext stream from my hardware to Alistair's software and instantly halved the cost of a teletext system," says Peter. "The only thing that the Pi can't do is overlaying from video, so things like subtitles and newsflash need an original hardware VBIT."

The Teefax server is actually an original Pi Model B running Subversion. "Apache handles user authentication. PHP scripts triggered by Cron scrape the BBC News website and update the news pages every day." Currently, there are seven authorised contributors to Teefax. "The real number is more because people are welcome to submit their own pages and designs and we will put them into Teefax for them." To do so, you can use Peter's wxTED page editor on a PC.

Meanwhile, Peter is currently working on a more flexible version of the VBIT system with a much faster update speed. "This actually has a commercial application in the betting industry where a small delay in reporting the 'off' in a horse race can be costly."



GETTING TELETEXT BACK ON THE TELLY

>STEP-01

Teefax server

The Teefax server is an original Raspberry Pi Model B running Subversion and Apache web server. PHP scripts scrape the BBC News website and convert stories to teletext pages.

>STEP-02

Pi client

With a client Pi's composite video output connected to a TV, teletext data is transmitted in normally unseen VBI (vertical blanking interval) lines of the video signal.

>STEP-03

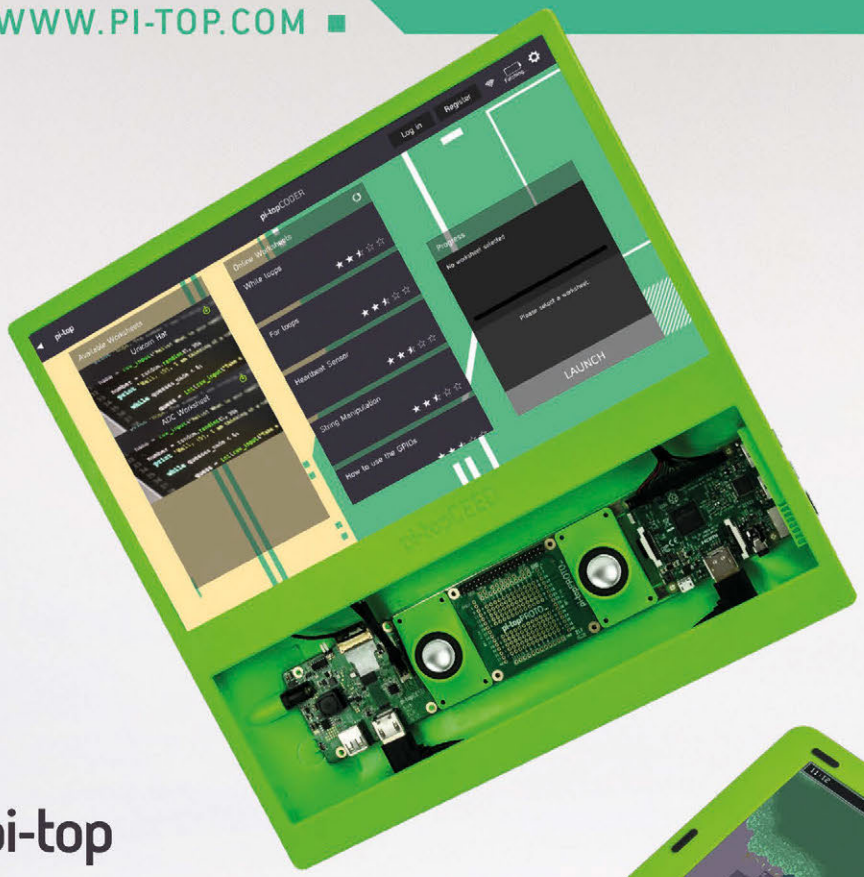
Teletext pages

Hit the teletext button on your TV remote to start viewing the pages as normal. Page numbers can be entered, or coloured buttons pressed to switch sections.

pi-top

LEARN
PLAY
CREATE

■ WWW.PI-TOP.COM ■



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- 14" HD Screen
- Modular Components

$114.99
without Raspberry Pi
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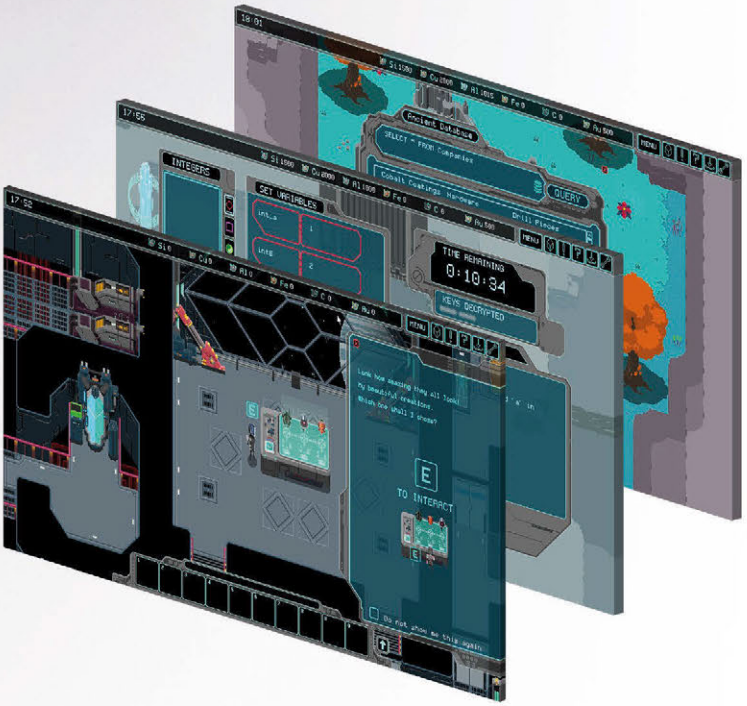
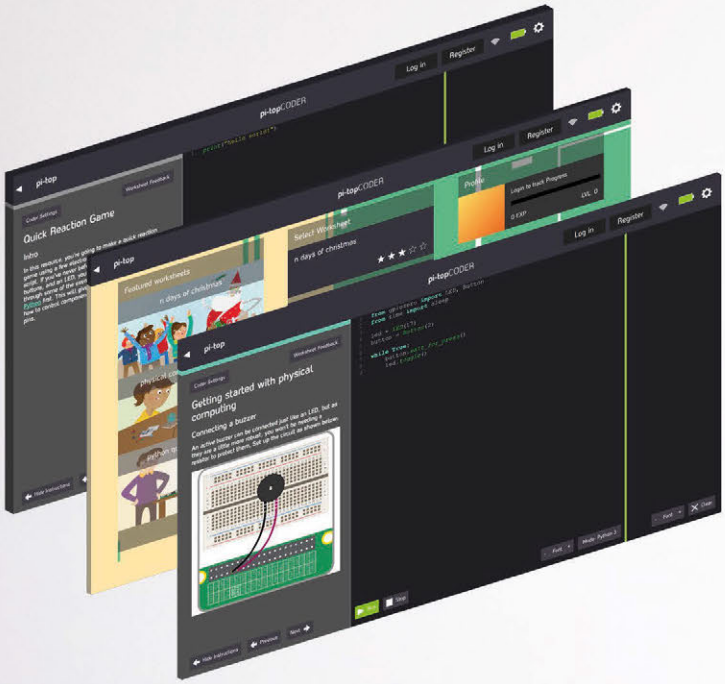
CEED**universe**

CEED**universe** is a world of fantasy grounded in computing reality! After crash landing on a strange new planet you will first encounter 'drag and drop' coding puzzles that improve your computational thinking skills.

Discover more about the planet you've landed on and the civilisation that used to inhabit it while learning harder and more complex concepts in fun and engaging ways! Before long you'll be writing your own conditional statements, loops and functions. Find out more about CEED**universe** at www.pi-top.com





pi-topCODER

Influenced by the workflow of makers and hackers, pi-top presents **pi-top**CODER - an integrated code editor which allows you to learn, write and test code all in one view. With intuitive syntax highlighting, dynamic views and customizable themes it makes for a versatile learning tool for your projects.

pi-topCODER also has every Raspberry Pi Foundation lesson plan created and will track and save your progress as you go through dozens of fun hardware and software projects.

pi-topPROTO

pi-topPROTO is a HAT compatible Add-on Board for your **pi-top** or **pi-top**CEED that allows you to prototype electronics. Create a Weather Station, HAM Radio, Heart Rate Monitor, or integrate any Arduino based maker kits into your own Raspberry Pi compatible prototyping board!

pi-topSPEAKER

Give a voice to your **pi-top** device with **pi-top**SPEAKER!

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- 2W per module
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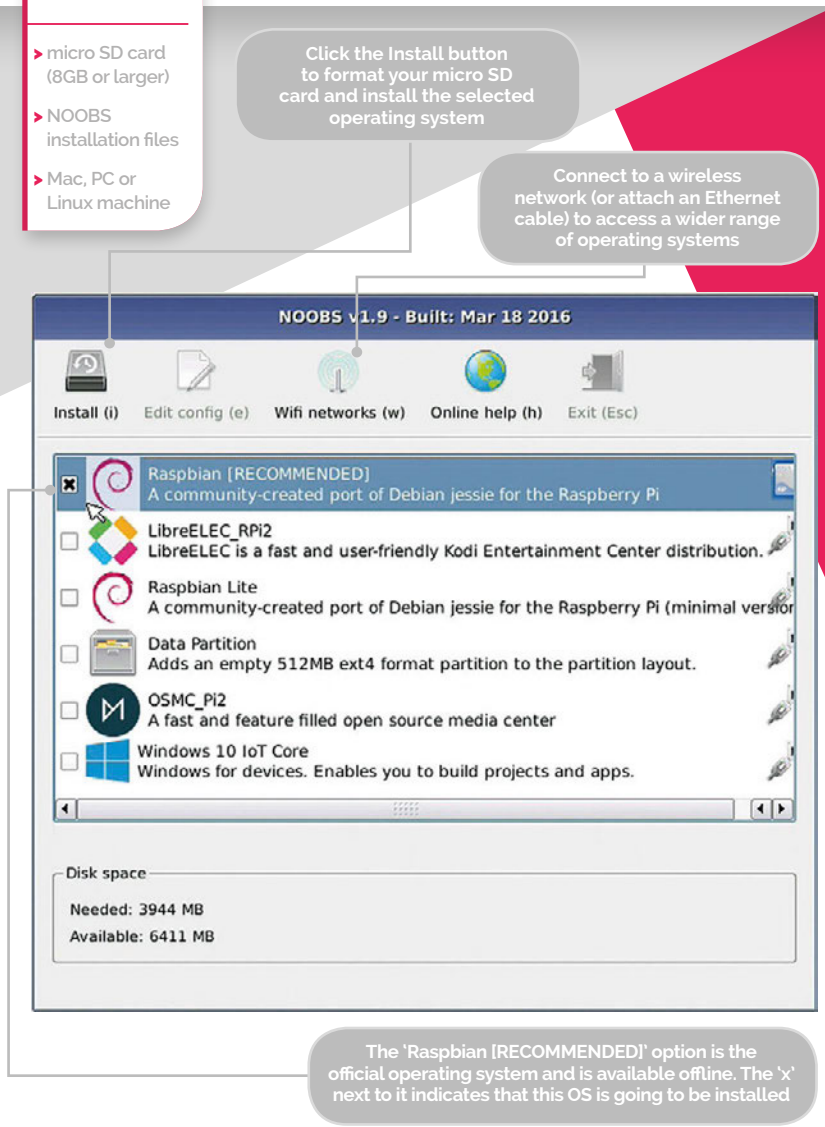
BEGINNER'S GUIDE TO NOOBS

The easiest way to set up a Raspberry Pi with Raspbian, and other operating systems, is to use the NOOBS installer

You'll Need

- micro SD card (8GB or larger)
- NOOBS installation files
- Mac, PC or Linux machine


Click the Install button to format your micro SD card and install the selected operating system
Connect to a wireless network (or attach an Ethernet cable) to access a wider range of operating systems
NOOBS v1.9 - Built: Mar 18 2016
Install (i)
Edit config (e)
Wifi networks (w)
Online help (h)
Exit (Esc)
Raspbian [RECOMMENDED]
A community-created port of Debian jessie for the Raspberry Pi
LibreELEC_RPi2
LibreELEC is a fast and user-friendly Kodi Entertainment Center distribution.
Raspbian Lite
A community-created port of Debian jessie for the Raspberry Pi (minimal version
Data Partition
Adds an empty 512MB ext4 format partition to the partition layout.
OSMC_Pi2
A fast and feature filled open source media center
Windows 10 IoT Core
Windows for devices. Enables you to build projects and apps.
Disk space
Needed: 3944 MB
Available: 6411 MB
The 'Raspbian [RECOMMENDED]' option is the official operating system and is available offline. The 'x' next to it indicates that this OS is going to be installed

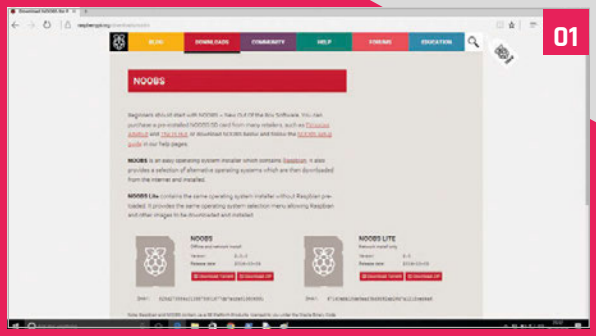
One of the things we love about the Raspberry Pi is just how easy it is to get started. A lot of this is down to a custom, simple-to-use installer called NOOBS.

NOOBS (or 'New Out Of Box Software', to give it its full name) is a unique installation image and an essential tool for newcomers. With NOOBS loaded on a micro SD card, you can install a wonderful range of operating systems for your Raspberry Pi.

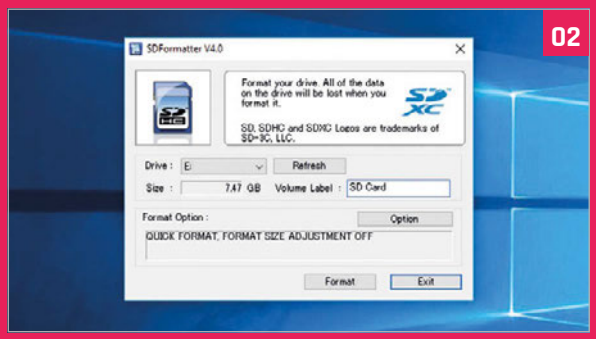
More importantly, you can speedily set up a new Raspberry Pi with Raspbian, the official operating system. When you start up a Raspberry Pi with NOOBS for the first time, you're given the option to install the Raspbian operating system. Connect the Raspberry Pi to a network and you'll also get a bunch of other operating systems to choose from.

From there it's just a matter of picking the operating system you want and letting NOOBS do its thing. The NOOBS installer wipes the micro SD card and sets up the operating system for you. When the Raspberry Pi restarts, you'll no longer see NOOBS, just your operating system.

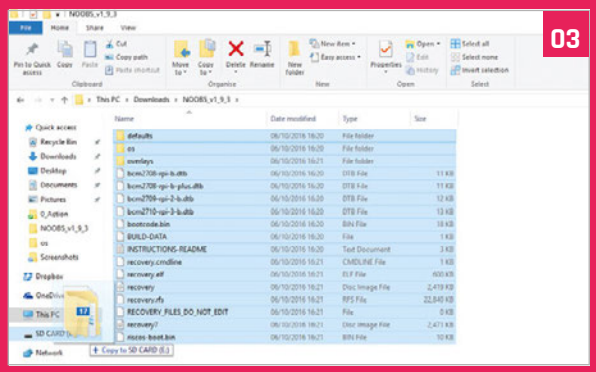
In this tutorial, we're going to help absolute newcomers install Raspbian Jessie with PIXEL (the official operating system). But don't forget: you can use NOOBS to experiment with other operating systems. NOOBS isn't just great for beginners; it's also ideal for exploring what other operating systems have to offer.



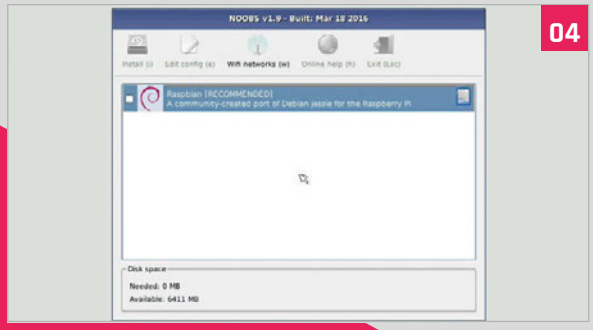
>STEP-01
Download NOOBS
Open your web browser and visit **raspberrypi.org/downloads/noobs/**. Click on Download ZIP under 'NOOBS Offline and network install'. Save the ZIP file to your Downloads folder and extract its contents.



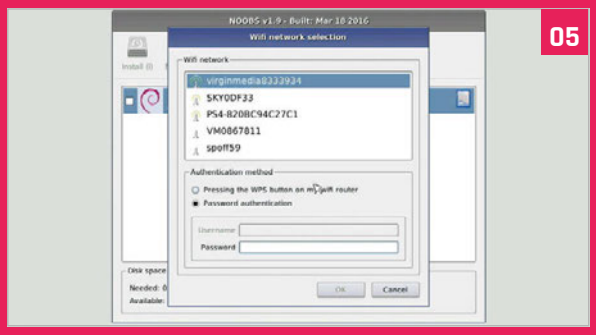
>STEP-02
SD card
Download SD Card Formatter from **sdcard.org** and open the program (click Yes in the User Account Control alert on Windows). Attach your micro SD card to the computer, and the card will appear in Drive. Enter 'SD CARD' in the Volume Label so you can identify it in the next step. Click Format (enter your password on a Mac). Answer OK to the alerts.



>STEP-03
Copy the files
Return to your Downloads and open the folder containing the NOOBS files. Make sure you're looking at the files inside the folder, and not the folder itself. Select all the files in the NOOBS folder and drag them to the SD CARD folder (in the sidebar).


04
NOOBS v1.9 - Built: Mar 18 2016
Raspbian [RECOMMENDED]
A community-created port of Debian Jessie for the Raspberry Pi
Disk space
Needed: 0 MB
Available: 6411 MB

>STEP-04
Power up
Eject the micro SD card from your computer. Place it into your Raspberry Pi and power it up. You'll be greeted by the NOOBS v1.9 screen. If you haven't connected to the internet, you'll only see a single option: 'Raspbian [RECOMMENDED]'.



>STEP-05
Connect to network
To access more operating system options, connect the Raspberry Pi to a network. Attach an Ethernet cable or click 'WiFi networks'. Choose your wireless network and enter the password. Click OK. You'll now see a wider range of options (as shown in the main image opposite).

>STEP-06
Install Raspbian
We're going to go with Raspbian, so click to put an X in the box next to 'Raspbian [RECOMMENDED]' and click Install. Click Yes in the alert window. The NOOBS software is copied to the micro SD card. NOOBS displays 'OS(es) Installed Successfully' when the software is installed. Click OK and the Raspberry Pi will restart and boot into the operating system.

MASTER THE RASPBERRY PI CONFIGURATION TOOL

Learn your way around the configuration tool found in Raspbian Jessie

You'll Need

- Raspberry Pi
- Raspbian Jessie with PIXEL

One of the best features in Raspbian Jessie these days is the desktop Raspberry Pi Configuration tool.

Located inside the **Preferences** option in the desktop **Menu**, this enables you to configure the hardware and software settings of your Raspberry Pi.

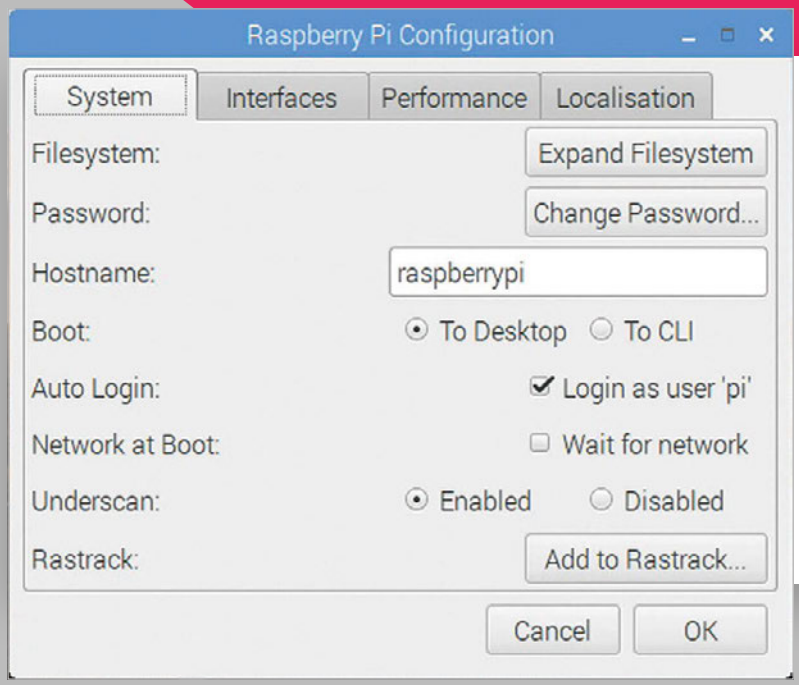
The Raspberry Pi Configuration tool works alongside the old raspi-config tool, which can still be accessed through the terminal using **`sudo raspi-config`**.

However, the new Configuration tool uses a GUI, making it much easier for newcomers. It offers the same options, but with a neater interface. Adjustments made in one tool affect the other. As a result, you can use either tool, or both.

Presently, the Raspberry Pi Configuration tool displays four tabs: System, Interfaces, Performance, and Localisation.

System is where you'll find the most useful tools. In this area you can expand the file system, change the password, and adjust login options. **Interfaces** contains options for activating hardware and software features. **Performance** is used to access overclock modes, and change the amount of RAM allocated to the GPU. The final tab, **Localisation**, enables you to adjust the locale, time zone, keyboard, and WiFi country for your Raspberry Pi.

There's a bunch of powerful features in the Raspberry Pi Configuration tool. As a result, learning its options makes you a better Raspberry Pi owner.



System

Options to expand the file system and change password and hostname sit alongside various login choices.

Interfaces

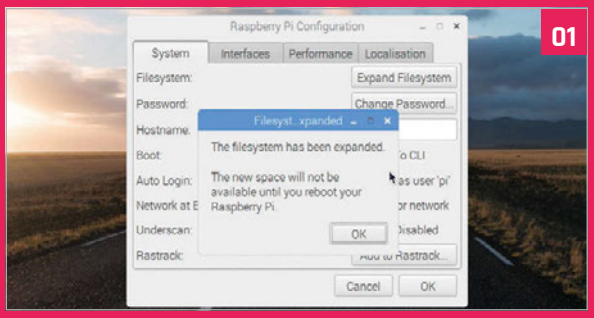
Support for the various hardware and software features, such as Camera Module, SSH, and VNC.

Performance

Overclocking and GPU memory options can improve the performance of a Raspberry Pi.

Localisation

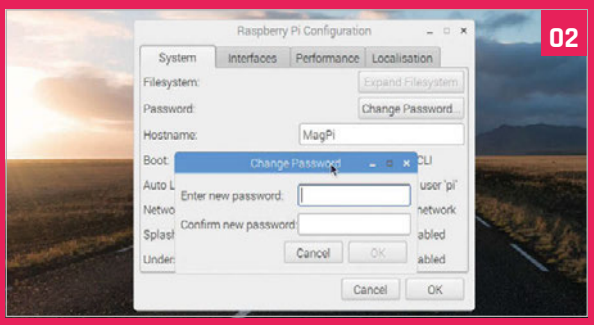
Set up an international keyboard, global WiFi options, and adjust the locale and time zone.



>OPTION-01

Expand file system

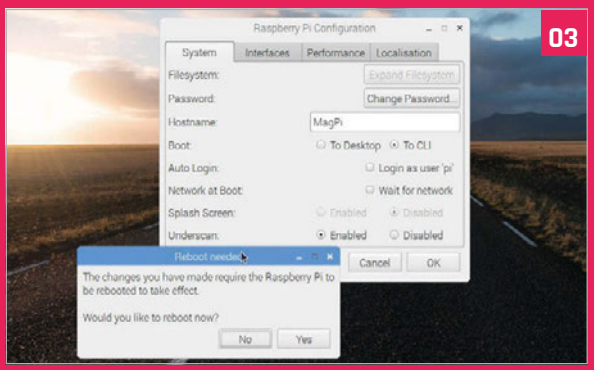
Open **Menu > Preferences > Raspberry Pi Configuration**. If you've installed Raspbian via an image file (instead of NOOBS), then the first thing you need to do is expand the file system. Expand Filesystem makes the whole of the SD card space available. Click on Expand Filesystem, then OK.



>OPTION-02

Hostname and password

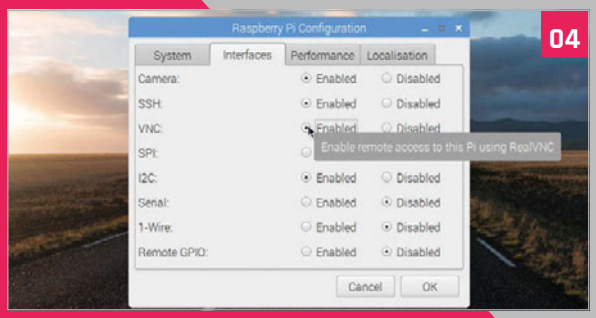
Customise your Pi by changing the hostname and password. Enter a new name for your Raspberry Pi and click Change Password. Enter the same password into both fields and click OK. Note that the hostname – used to identify the Pi on your network – isn't the same as your user name (which remains 'pi').



>OPTION-03

Login options

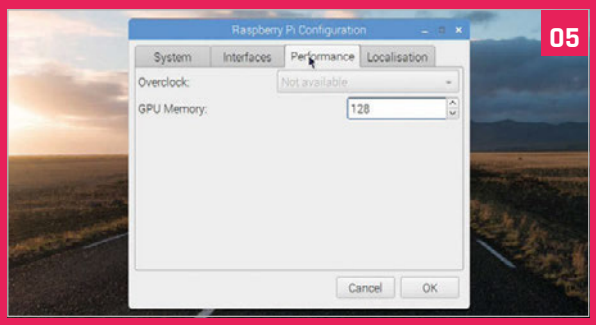
Below the Hostname setting sit various boot options. Choose **To CLI** to boot into the command line instead of PIXEL. You can also opt to disable the splash screen and/or remove the auto login. You need to restart Raspbian for any of these to take effect. Click OK and Yes to reboot your Raspberry Pi.



>OPTION-04

Interfaces

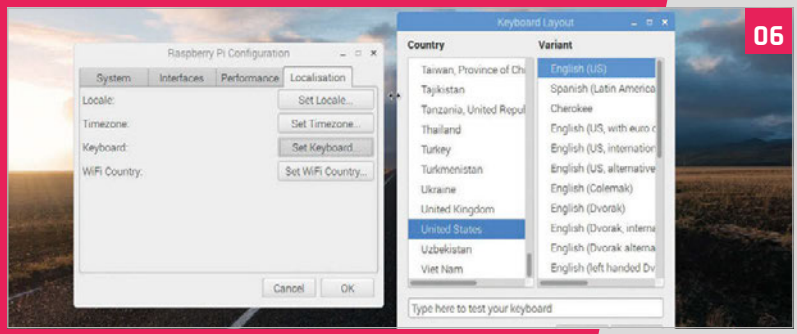
Reopen the Configuration tool and click on Interfaces to view the available options. Set Camera to Enabled if you plan on using the Raspberry Pi Camera Module. Now you'll be able to take images directly from the camera. Set VNC to Enabled if you plan on using VNC to remotely access your Raspberry Pi.



>OPTION-05

Performance

Click on Performance to view the two options here: Overclock and GPU Memory. Overclocking isn't available for the Raspberry Pi 3 yet, so this option will be greyed out. You can adjust the amount of RAM, in megabytes, allocated to the GPU (64 is the default, and is fine for most tasks). Set it to 128 to experiment with higher GPU memory.



>OPTION-06

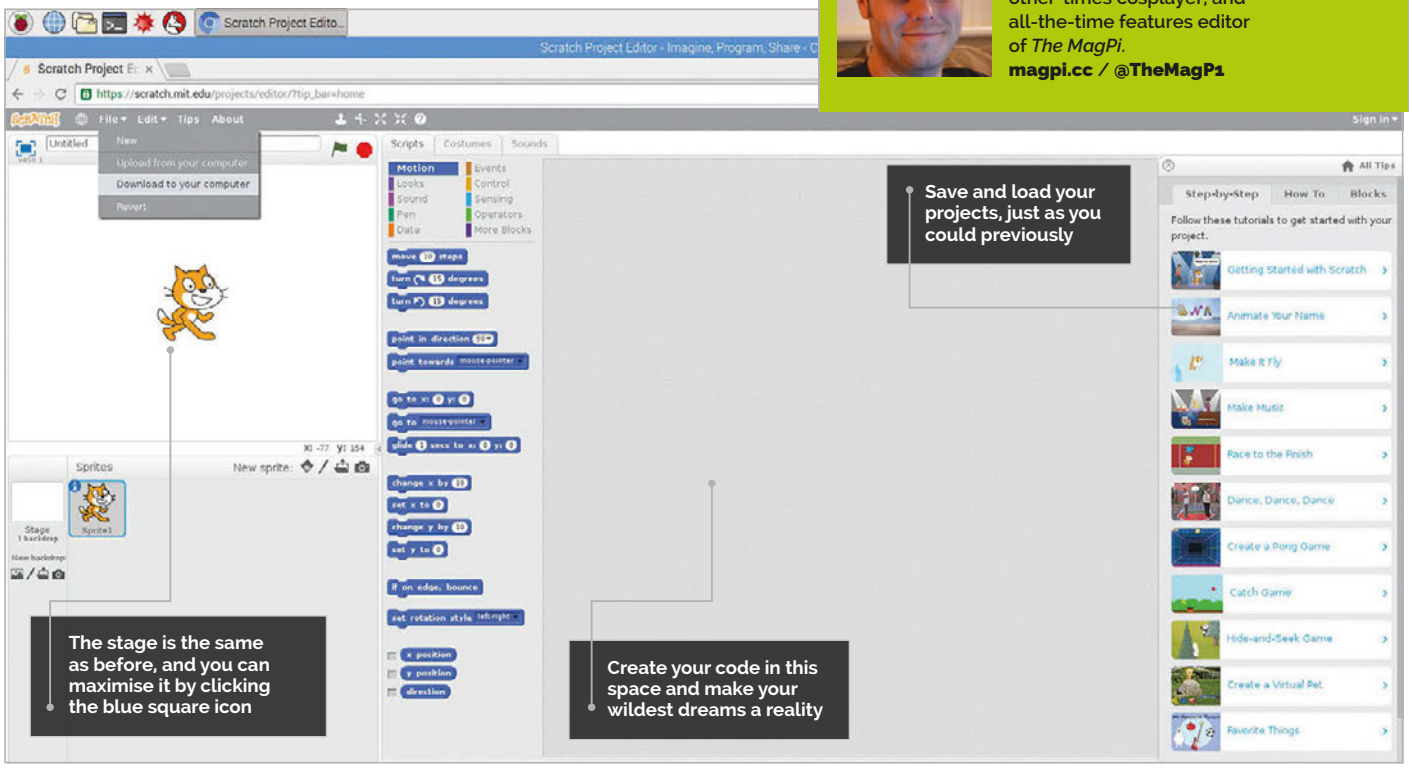
Localisation

Under the Localisation tab sit various international options. Click on Set Keyboard if you're using an international keyboard. If you own a US keyboard, click Set Keyboard. Now choose United States under country and English (US) as the Variant. Click OK and select Yes to reboot the Raspberry Pi.

ROB ZWETSLOOT

Tinkerer, sometime maker, other-times cosplayer, and all-the-time features editor of *The MagPi*.

magpi.cc / @TheMagPi


Save and load your projects, just as you could previously
The stage is the same as before, and you can maximise it by clicking the blue square icon
Create your code in this space and make your wildest dreams a reality

SCRATCH 2.0 ON RASPBERRY PI

You'll Need

- Raspberry Pi 3

Get access to the upgrade for Scratch on your Raspberry Pi via some very easy steps

Scratch is an amazing piece of software that has helped many people take their first steps into the world of coding. We've done a fair few Scratch tutorials ourselves on the Raspberry Pi, but they always use Scratch 1.4, which is installed on the Raspberry Pi itself.

Thanks to the recent updates to Raspbian with PIXEL, the official Raspberry Pi operating system, you can finally upgrade to the latest version of Scratch. It's very easy to do as well, so get your Raspberry Pi out and let's begin.

>STEP-01

Upgrade Raspbian

You'll need to do this in one of two ways: upgrading from a previous install, or downloading the latest release of Raspbian with PIXEL (**magpi.cc/2ejN6sk**) and writing it to a new SD card.

To upgrade from an earlier version of Raspbian to Raspbian PIXEL, open up the terminal and type the following:

```
sudo apt-get update
sudo apt-get dist-upgrade
```

This may take a while and will probably require a reboot once you're done. You'll then be in the latest version of Raspbian with the PIXEL desktop.

>STEP-02

Update your Raspberry Pi

The ability to use Scratch 2.0 is tied to the new browser, Chromium, being able to use Adobe Flash. This isn't installed as standard with PIXEL, so you'll need to update to get the Flash library. If you did a dist-upgrade to get PIXEL, then you may be able to

skip this step. Otherwise, close Chromium if you have it open, go to the terminal, and enter the following:

```
sudo apt-get update
sudo apt-get upgrade
```

At some point during the upgrade process, you'll be asked in the terminal window if you want to install Flash; just press **ENTER** to accept. Once everything is updated, you're ready to go.

>STEP-03

Find Scratch 2.0

Scratch 2.0 is not a program you can install on your Raspberry Pi, but instead is an online editor you can use through the Chromium browser. This is good, as it means you can use Scratch anywhere, taking your projects easily between computers. It also means your old Scratch projects for Scratch 1.4 on the Raspberry Pi will still work on that version installed on the Pi.

Open up the Chromium browser and head to the following address: **scratch.mit.edu**.

>STEP-04

Browsing the website

From the main page, you can head straight to the editor by clicking the Create button at the top-left of the screen, or you can browse some examples if you want something more than just a blank canvas. There are also some games and programs that have been uploaded onto the website by other users to try out.

Once you click through to anything, though, you'll need to right-click on the puzzle piece on the screen and then select 'Run this plug-in' for Flash to start working. It might take a moment to load the interface.

>STEP-05

Make something

Scratch 2.0 works in mostly the same way as Scratch 1.4, although there are some extra features you can make use of. As before, you place blocks to create code with loops, variables, and triggers. You can also upload sprites and music from your computer if you want to use more than just the defaults available. You can then save your files to your Raspberry Pi by going to File and then 'Download to your computer'.

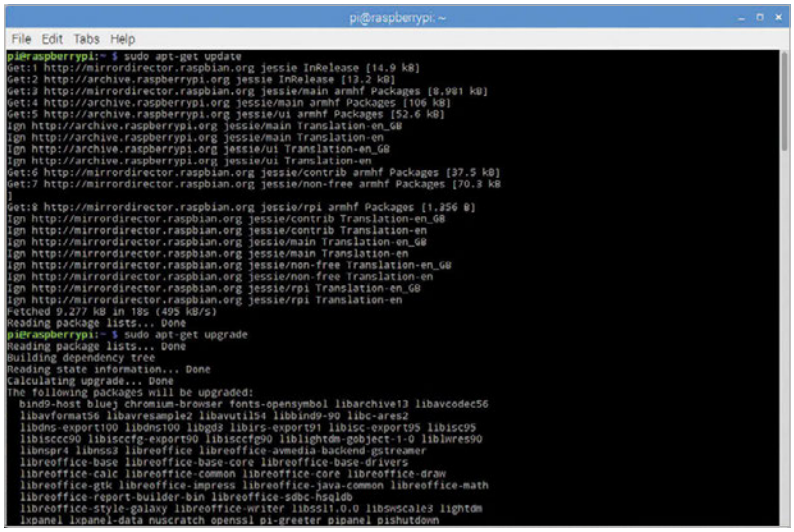
You'll also notice an 'Upload from your computer' option; this can be used to load the files you make in Scratch 2.0, and upload some of your Scratch 1.4 projects as well.

>STEP-06

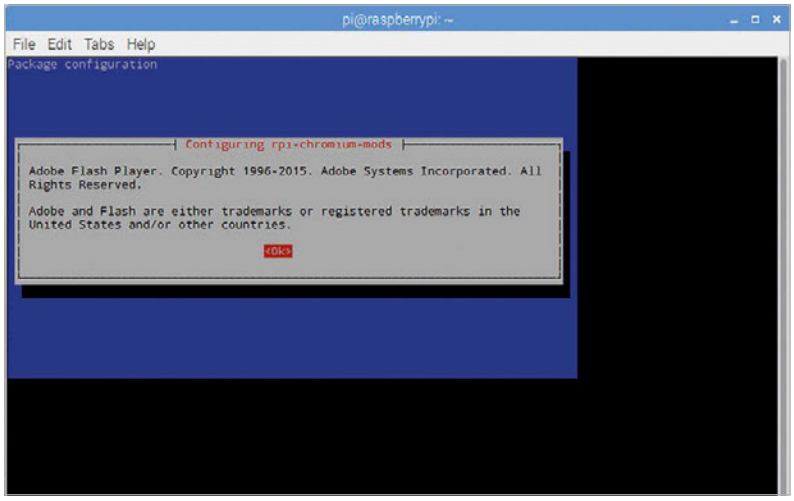
Compatibility

Scratch 2.0 projects can sometimes have a hard time working on the version of Scratch that's installed on the Raspberry Pi. As long as you have an internet connection, it shouldn't be a problem, as you can run them in the browser. If you want to convert the files to work offline in Scratch 1.4, you can try out the Retro Converter here: **magpi.cc/2dtEUYW**.

It's not perfect, though, so you may need to make some tweaks once you've done the conversion to get it working properly on the older version of Scratch.



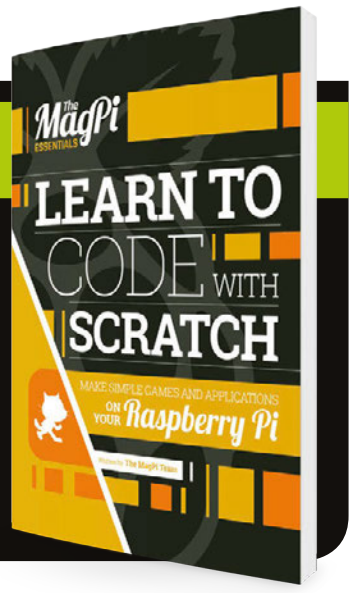
Above Updating your Raspberry Pi is essential – make sure you do it regularly


pi@raspberrypi: ~
File Edit Tabs Help
Package configuration
Configuring rpi-chromium-mods
Adobe Flash Player. Copyright 1996-2015. Adobe Systems Incorporated. All Rights Reserved.
Adobe and Flash are either trademarks or registered trademarks in the United States and/or other countries.
<Ok>

Above This screen will show up during the upgrade process – just press ENTER to install Flash

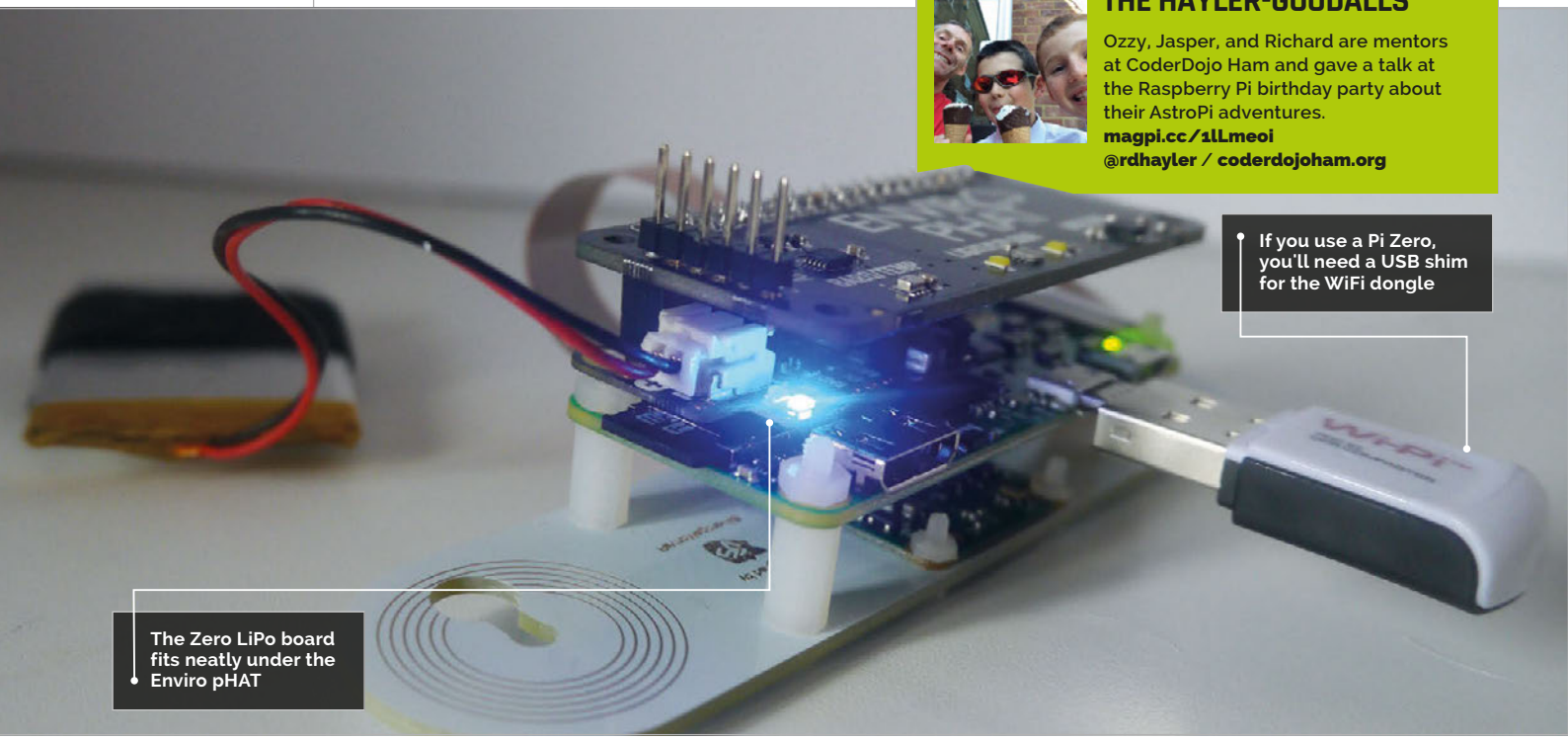
LEARN TO CODE WITH SCRATCH

If you want to get stuck in with Scratch and make some cool stuff, you should check out our Scratch Essentials book, *Learn to Code with Scratch*. While it's written for Scratch 1.4 on the Raspberry Pi, the projects should mostly work on 2.0 on the web as well. You can find the free PDF, along with other ways to get it, here: **magpi.cc/Scratch-book**



THE HAYLER-GOODALLS

Ozzy, Jasper, and Richard are mentors at CoderDojo Ham and gave a talk at the Raspberry Pi birthday party about their AstroPi adventures.
magpi.cc/1LLmeoi
@rdhayler / coderdojoham.org



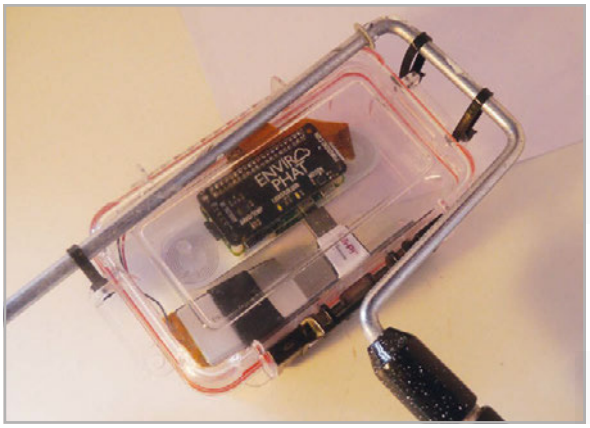
AQUAPI-CAM

Explore the underwater world with a Raspberry Pi camera

You'll Need

- A transparent, waterproof box **magpi.cc/2e8beBX**
- Pi Camera Module
- Portable power source
- hostapd and dnsmasq packages
- Python Flask library
- WiFi dongle (if not using a Pi 3)
- Enviro pHAT (optional) **magpi.cc/29NHB3T**
- ZeroView (optional) **magpi.cc/2e8ghWt**

There are plenty of underwater sports cameras available, but they can be quite expensive, especially if you want to control them remotely. In this tutorial we're going to use readily available Pi add-ons to make a cheaper, customisable camera unit. There are lots of options and alternative sources of components for a project like this. For example, the Pimoroni Enviro pHAT is a really useful option that can report back information about the environment in which the camera is operating, especially how much light is available. There's a fair bit of software configuration involved, but example config files are in the GitHub repo for this article (**magpi.cc/2e8dtFk**).



>STEP-01

Find a suitable container

This needs to be watertight and have at least a see-through lid. You can find Tupperware boxes with a very tight seal, but these tend to be translucent rather than transparent. The size of box will probably determine your choice of Pi and power source. Zeros are great as they're so small, but then you'll need a WiFi dongle and shim. You can also save space by using a LiPo battery instead of a power bank, although you'll need a boost regulator too, such as the Pimoroni Zero LiPo.

>STEP-02

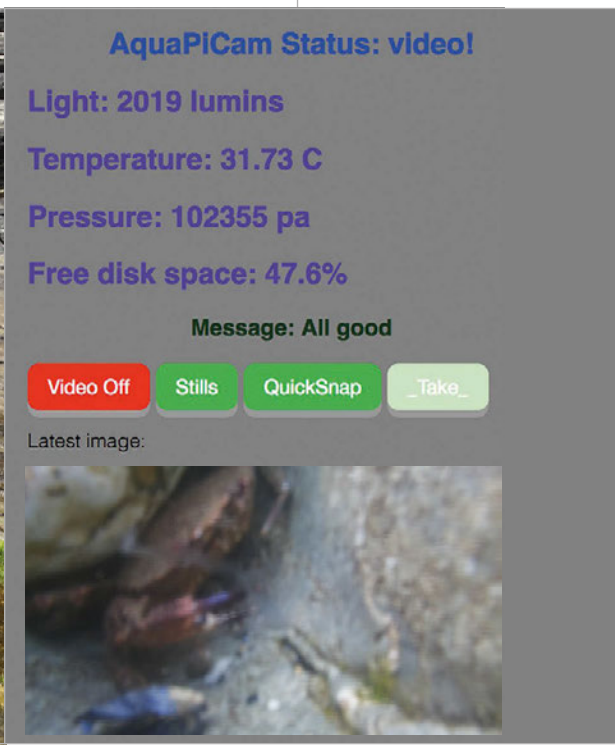
Configure your Pi to be a WiFi access point

Start from a fresh Raspbian Jessie Lite SD card and install the following:

```
sudo apt-get update
sudo apt-get install -y dnsmasq hostapd python3
python3-dev python3-flask python3-picamera
```

First, configure your wireless interface to have a static IP address by editing **/etc/network/interfaces**. Then set it to not use DHCP by adding this line:

```
denyinterfaces wlan0
```



Above left You'll still have to get pretty close to the water yourself
Above right The web interface shows environmental information and lets you control the camera

…to the end of your **/etc/dhcpcd.conf** file. Next, create the **/etc/hostapd/hostapd.conf** file, using the example in this tutorial's GitHub repository as a template. Change the **`interface`**, **`ssid`**, and **`passphrase`** parameters as needed. Finally, edit **/etc/dnsmasq.conf**, ensuring that the IP addresses are consistent with your settings in **/etc/network/interfaces**. Then reboot!

>STEP-03

Add the Enviro pHAT

You have the option of soldering this board directly onto the Pi's GPIO pins, or you can use the supplied female header if you want to reuse it in other projects. After that, install the Python library and dependencies using the following command:

```
curl -sS https://get.pimoroni.com/envirophat | bash
```

The library comes with some example programs and you should run these to test that everything is working correctly.

>STEP-04

Fit everything into your container

To cut down on reflections and get the best possible images, the camera should be as close to the transparent side of your container as possible. The ZeroView from the Pi Hut is a clever mounting plate that uses suction cups and will also hold your Pi securely. Alternatively, you could make a mount out of cardboard and glue this to the inside of the container. Velcro tape can be a good solution for power sources (which normally need to be removable for recharging).

>STEP-05

Add some code, HTML and CSS

Clone the entire **Flask** folder from the project repository onto your Pi. Flask is a small web framework written in Python which allows you to create simple web services; in this case, it's a webpage that allows us to see data from the Enviro pHAT and the latest captured images. We can also switch between recording modes (movie or continuous still frames) or take photos on demand. This control of the camera is achieved via the excellent Python **picamera** library. You could enhance the project by adding additional exposure and shutter speed controls to your interface if you want.

>STEP-06

Set the code to run at boot

To set the AquaPiCam program to run when the Pi boots up, add this line to your **/etc/rc.local** file, immediately above the **`exit 0`** line:

```
python3 /home/pi/Flask/apc.py &
```

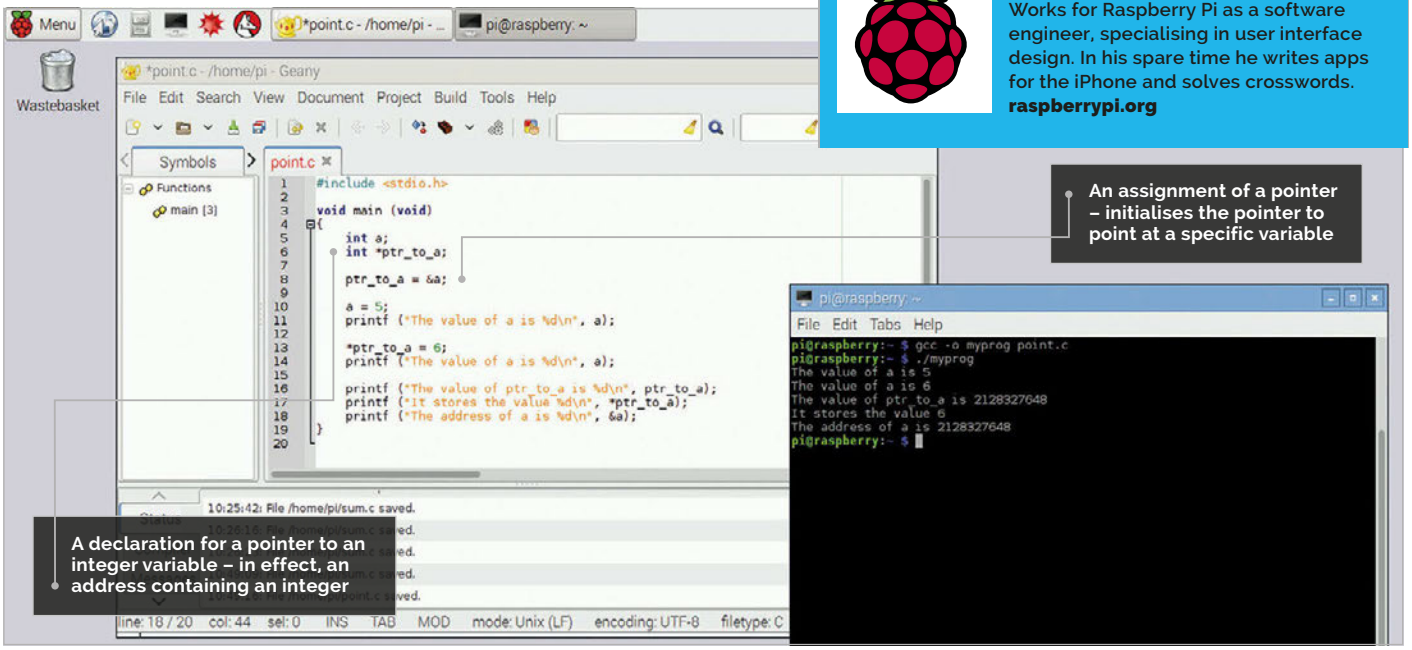
It's also a good idea to configure the Pi to only boot to the command line, using:

```
sudo raspi-config
```

…and selecting 'console' under option 3.

Now go and find somewhere wet! You might want to run a few tests in the bath before venturing further afield!

SIMON LONG
Works for Raspberry Pi as a software engineer, specialising in user interface design. In his spare time he writes apps for the iPhone and solves crosswords.
raspberrypi.org


An assignment of a pointer – initialises the pointer to point at a specific variable
A declaration for a pointer to an integer variable – in effect, an address containing an integer

AN INTRODUCTION TO C POINTERS

PART 05

Pointers: variables have addresses as well as names...

The term 'pointer' has struck fear into the heart of many a beginner C programmer, but once you've got your head around them, they are a very useful feature of the language. They aren't actually that complicated in reality.

Remember when we looked at the declaration of variables? Declaring a variable – telling the compiler what type it is and what it's called – before you can use it is necessary in C, because the declaration enables the compiler to allocate a block of memory to store the variable. So for every variable you declare, there's a block of memory which is set aside by the compiler for that variable, and the compiler remembers which particular block of memory is used for each variable.

* AND &

When first learning about pointers, you may find it helpful to say out loud what a line of code is doing: an * is "what is pointed to by", and an & is "the address of". Once you have got those two ideas fixed in your head, you've pretty much understood pointers!

What is a pointer?

A pointer is just the address of a block of memory with a variable in it – that's all there is to it. So if you declare a variable and a pointer to that variable, you can access the value in that block of memory in two ways: either with the variable name, or with the pointer.

Let's look at a simple example:

```
#include <stdio.h>
void main (void)
{
      int a;
      int *ptr_to_a;
      ptr_to_a = &a;
      a = 5;
      printf ("The value of a is %d\n", a);
      *ptr_to_a = 6;
      printf ("The value of a is %d\n", a);
      printf ("The value of ptr_to_a is
                  %d\n", ptr_to_a);
      printf ("It stores the value %d\n",
                  *ptr_to_a);
      printf ("The address of a is %d\n",
                  &a);
}
```

Taking it line by line, the first line is one we're already familiar with: we declare an integer variable called **a**. But what's this?

```
int *ptr_to_a;
```

This looks like it's declaring another integer variable, doesn't it? But look more carefully: the asterisk (*****) at the start of the variable name indicates that this isn't declaring an integer variable, but a pointer to an integer variable.

So we now have an integer variable called **a**, and we have a pointer to an integer variable, called **ptr_to_a**. But neither of these actually have a value in them yet. It's all very well calling the pointer **ptr_to_a**, but it has no idea what (or where) **a** is, so let's fix that:

```
ptr_to_a = &a;
```

This is the important bit! In C, the symbol **&** before a variable name means 'address of the variable', so **&a** means 'the address in memory of the variable **a**'. And as we said above, a pointer is the address of a variable. So this line initialises **ptr_to_a** to be the address of **a**; **ptr_to_a** is now a valid pointer to the variable **a**, so we can now use it.

The next two lines are familiar; we set **a** to be 5, and just to check that worked, we print its value. So let's try doing the same thing, but with the pointer:

```
*ptr_to_a = 6;
```

We're using the asterisk differently here. When declaring a variable, putting an * before its name indicates the variable is a pointer. But once the pointer exists, putting an * in front of its name means 'the variable pointed to by this pointer'; this is known as dereferencing the pointer. So this line tells the compiler to set the variable pointed to by the pointer **ptr_to_a** to 6. We know that the variable pointed to by **ptr_to_a** is **a**, so this line is just another way of setting **a** to 6; and if we print the value of **a**, we find it has changed to 6.

The next lines should help you to understand the relationship between pointers, variables, and addresses:

```
printf ("The value of ptr_to_a is %d\n",
ptr_to_a);
```

In this line, we're printing the value of **ptr_to_a**; not the value it's pointing at, but the value of the pointer itself. This prints a very large number, as it's the address in memory where **a** can be found.

```
printf ("It stores the value %d\n", *ptr_to_a);
```

In this line, we're printing the value pointed to by **ptr_to_a**; note the asterisk before the name. This prints the value of **a**.

```
printf ("The address of a is %d\n", &a);
```

Finally, in this line, we're printing the address of **a** itself, the same as the value of **ptr_to_a** we printed above.

The crucial thing to remember when working with pointers is this: you can't just declare a pointer, you need to also declare and associate the variable you want it to point to. When a pointer is created, it points at a random location in memory; if you try and write something to it, you can cause all sorts of errors. Always make sure your pointers are pointing at something before doing anything with them.

Void pointers and casting

You can also define a pointer without saying what type of variable it's pointing to; this is a void pointer, written as **void ***. A pointer is just an address in memory, so we don't necessarily need to know what's at that memory. To use a void pointer, you need to cast it: tell the compiler what sort of pointer to treat it as...

```
#include <stdio.h>
void main (void)
{
      int intval = 255958283;
      void *vptr = &intval;
      printf ("The value at vptr as an int
            is %d\n", *((int *) vptr));
      printf ("The value at vptr as a char
            is %d\n", *((char *) vptr));
}
```

We initialise the void pointer **vptr** to point to an integer variable called **intval**.

In the first **printf** statement, we insert **(int *)** in front of **vptr** before we dereference it using *****. This casts **vptr** to an integer pointer, and so the value of **intval** is printed as an integer.

In the second **printf** statement, we insert **(char *)** in front of vptr before we dereference it. This casts **vptr** to a char pointer, and so what is printed is the value of the char which makes up the first byte of **intval**.

What do you use pointers for?

Why bother with pointers? We can already access a variable with its name. There are several ways in which pointers are useful, which we will explore in the future. But a few of the important ones are:

FUNCTION CALLS – in the next instalment we will look at how to split up C code into functions; pointers are very useful for allowing a function to return multiple values.

STRING HANDLING – in C, a string is a continuous block of memory with a letter stored in each byte; pointers make it possible to perform efficient operations on strings.

ARRAYS – C allows array variables – lists of values of the same type – which, like strings, are stored in a continuous block of memory; pointers make accessing arrays easier and more efficient.

INCREMENTING POINTERS

You can use **++** and **--** on pointers, but you need to be careful. **(*a)++** increments the value pointed to by **a**, but ***(a++)** increments the pointer itself rather than the value it points at; this will move **a** to point at the memory address immediately after **a**.

ALWAYS HAVE SOMETHING TO POINT TO!

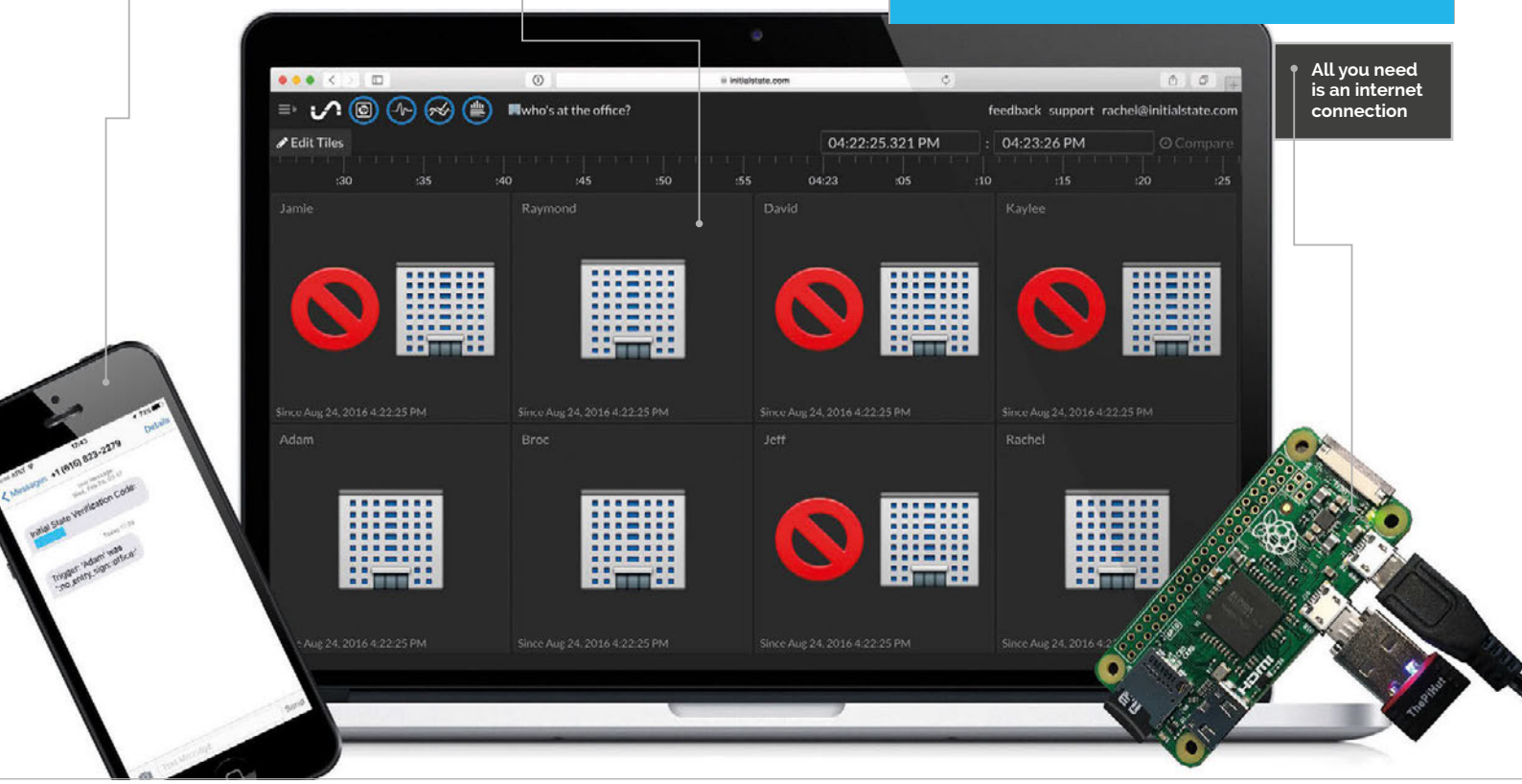
It's worth stressing this again: a pointer is not a piece of memory, it's just an address of memory. If you want to do anything with a pointer, you need to declare something for it to point to as well as the pointer itself.

MEMORY

Pointers are one of the ways C allows (or in some cases forces) you to think about what the actual hardware of your computer is doing; a good understanding of pointers gives you a good understanding of how the compiler handles memory.

RACHEL-CHLOE GREGORY

Rachel-Chloe is an engineering grad who now gets to make Internet of Things projects for a living at Initial State, a data visualisation service. **initialstate.com**



KNOW WHO'S AT HOME WITHOUT ANY SENSORS

You'll Need

- USB WiFi adapter **magpi.cc/2dDzU2A**

Set up a sensor-free presence detector to let you know when someone's close enough to connect to the WiFi

Looking for an easy and useful project for that Pi you just have lying around? Find out who's home and who's not, or when your favourite coworkers are at the office, with just a Pi and an internet connection! This WiFi-based presence detector will take hardly any time at all, and you'll suddenly have a base for triggering all sorts of things when someone is detected, like that theme music you've always wanted.

Presence detection

The way that we're going to detect 'presence' is by scanning the WiFi network for certain devices' MAC addresses, the unique identifiers that your phone or laptop gives when connecting to a network. Detecting devices can also be done via Bluetooth; however, not everyone will always have their phone's Bluetooth turned on, so WiFi should be a bit more reliable.

Update your Pi and install arp-scan, an Address Resolution Protocol packet scanner that shows every active IPv4 device on your local internet:

```
sudo apt-get update
sudo apt-get install arp-scan
```

Once arp-scan is installed, you can test it with:

```
sudo arp-scan -l
```

You should see a list of devices and corresponding MAC addresses run down the screen; it could take a little while to load if on a large network.

A quick Google search will tell you how to find your particular phone/laptop MAC address, usually a series of 12 letters and numbers separated by colons. You can check to see if your device appears on the

arp-scan list of devices if the following command returns an address:

```
sudo arp-scan -l | grep DEVICEMACADDRESS
```

If your phone was found, the command will output its address. If it wasn't found, make sure that it's connected to the same WiFi network as the Pi (or vice versa). You may also need to wake up your device, as many devices disappear when they 'sleep'.

Initial State

We're going to use Initial State to create a real-time dashboard showing who's at the office and who isn't.

Go to **app.initialstate.com/#/register/** and create a new account. Install the Initial State Python module on your Pi:

```
\curl -sSL https://get.initialstate.com/
       python -o - | sudo bash
```

You will be prompted to create an example script; this isn't essential to installing the module, but can help test your ability to stream to Initial State.

The code

You can clone the GitHub repo to get the **presence.py** script:

```
git clone https://github.com/initialstate/
pi-sensor-free-presence-detector.git
```

We use threading to create separate pieces of code that run at the same time as each other. This allows us to look for more than one device on the network more reliably. The subprocess module lets us call arp-scan within our Python script.

To customise the script, change the arrays of names and addresses to match your own. In this use case, we're tracking who's at the office, so we have an array with our names. The address array contains the corresponding MAC addresses for our phones. If you want to add more devices, simply add more values to both arrays.

You'll also need to replace **YOUR_ACCESS_KEY** with your Initial State access key, which can be found on your Initial State Account page.

Run the script with:

```
sudo python presence.py
```

Watch what prints to the terminal to make sure your devices are being detected, and that streaming is working. Head over to Initial State to check out your dashboard!

Run from boot

To make this truly useful and reliable, we need to handle any network issues. We found the easiest solution to be rebooting the Pi whenever the network connection drops. First, we need to create a script to check the WiFi and then trigger shutdown:

```
sudo nano /usr/local/bin/checkwifi.sh
```

Place the following inside the file, making sure to replace the IP address with the IP address of your router:

```
ping -c4 IP_ADDRESS > /dev/null

if [ $? != 0 ]
then
  sudo /sbin/shutdown -r now
fi
```

The ping checks for a connection. If it returns with a non-zero exit code, the script sends the shutdown command.

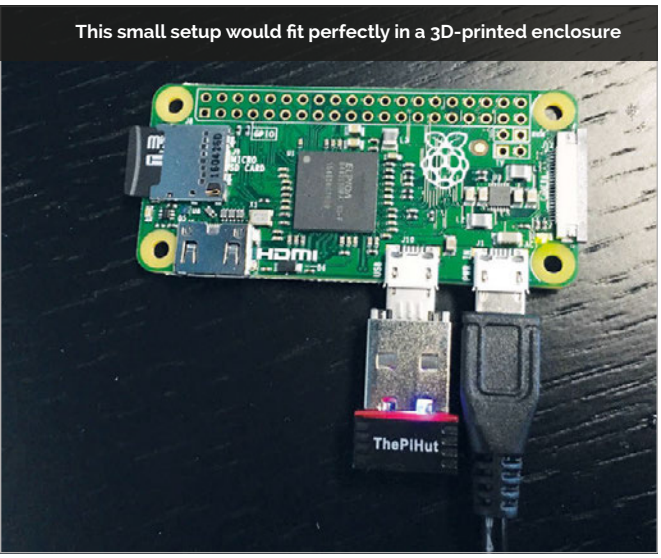
Save and exit the script. Now make sure its permissions are in order:

```
sudo chmod 775 /usr/local/bin/checkwifi.sh
```

Running a script from boot on the Pi is pretty straightforward with the service **crontab**:

```
sudo crontab -e
```

Pick your favourite text editor (such as nano) and at the bottom of the file, under all of the comments, add **@reboot nohup sudo /usr/bin/python /home/pi/presence.py &** to run the **presence.py** script. If you named your script something else or put it in a different directory, replace **/home/pi/presence.py** with the correct path. Then, under that, add ***/5 * * * * /usr/bin/sudo -H /usr/local/bin/checkwifi.sh >> /dev/null 2>&1** to run the **checkwifi.sh** script. Exit **crontab** and reboot the Pi to run your new presence detector!



This small setup would fit perfectly in a 3D-printed enclosure

Language
>PYTHON 3

DOWNLOAD:
magpi.cc/2dDyuoV

TRIGGERING AN ACTION

Easily set up SMS or email alerts within Initial State or customise the code to make the Pi trigger something.

EMOJIS

You can change the emoji icon in your dashboard to represent your personal use case, such as a house or hospital.

MIKE'S PI BAKERY

MIKE COOK

Veteran magazine author from the old days and writer of the Body Build series. Co-author of *Raspberry Pi for Dummies*, *Raspberry Pi Projects*, and *Raspberry Pi Projects for Dummies*.
magpi.cc/1NqIdHU

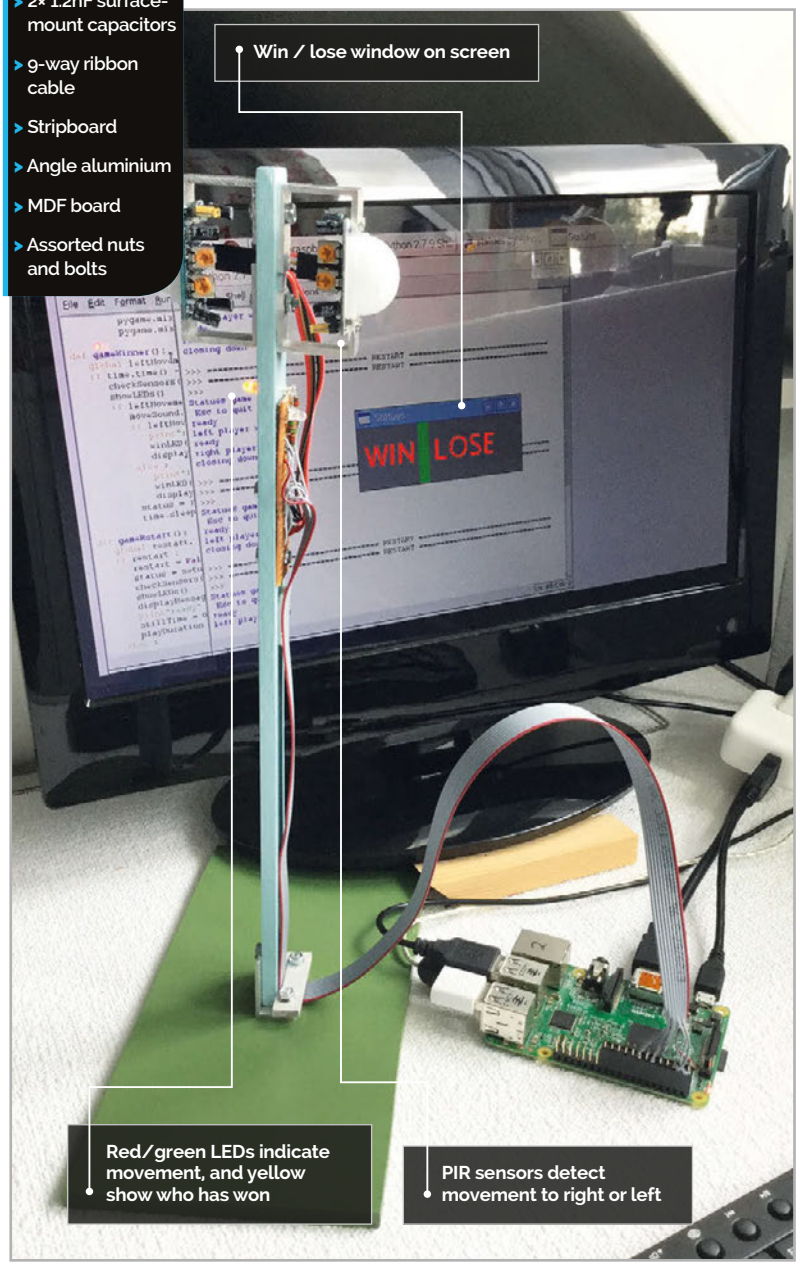
You'll Need

- 2× HC-SR501 PIR sensors or equivalent
- 2× Common anode red / green LEDs – diffused case
- 4× 150Ω resistors
- 2× 1.2nF surface-mount capacitors
- 9-way ribbon cable
- Stripboard
- Angle aluminium
- MDF board
- Assorted nuts and bolts

STATUES PI

THE ULTIMATE STATUES JUDGE

Play the classic statues game with the Raspberry Pi as the arbiter, which also supplies the music


Win / lose window on screen
WIN
LOSE
Red/green LEDs indicate movement, and yellow show who has won
PIR sensors detect movement to right or left

The coming festive season often involves playing games, and musical statues is one of the classic favourites. For anyone who is not familiar with the game, it involves players dancing around to music. When the music stops, they must adopt a pose and hold it like a statue; the player first to move is out. In this version there are two players who face off against each other, and PIR (passive infrared) sensors detect who moves first. For some unknown reason, all participants seem to also pull a funny face when freezing.

The circuit

The sensor we chose to use is the very low-cost HC-SR501 PIR, although most others would probably work. Unfortunately, it does not have an ideal operating characteristic for this application, but luckily this is easy to fix. In the retrigger mode, the output goes high for a minimum amount of time set by an adjustment pot. Then, if more movement is detected during the high output time, the timer is triggered again and the output doesn't go low until no movement is detected for the minimum high time. When the output goes low, it stays low for a fixed time and then the sensor is activated again, ready to respond to movement. While this behaviour is fine, what is not suitable for our game arbiter is the actual duration of these times. Even with the adjustment pot set on the minimum value, the delay obtained on the pot is approximately 5 seconds. The fixed time to activate the sensor again is about 3 seconds and has no adjustment control. Therefore we require a bit of hacking to shorten these times. This is done simply by replacing two capacitors with smaller ones. These are surface-mount ones; that might put some people off, but it is simple if you have a pair of tweezers and a fine-tipped soldering iron.

Wiring up these sensors is easy: just 5V and ground and the output is an open drain configuration, so simply wire it up to any GPIO pin and enable the

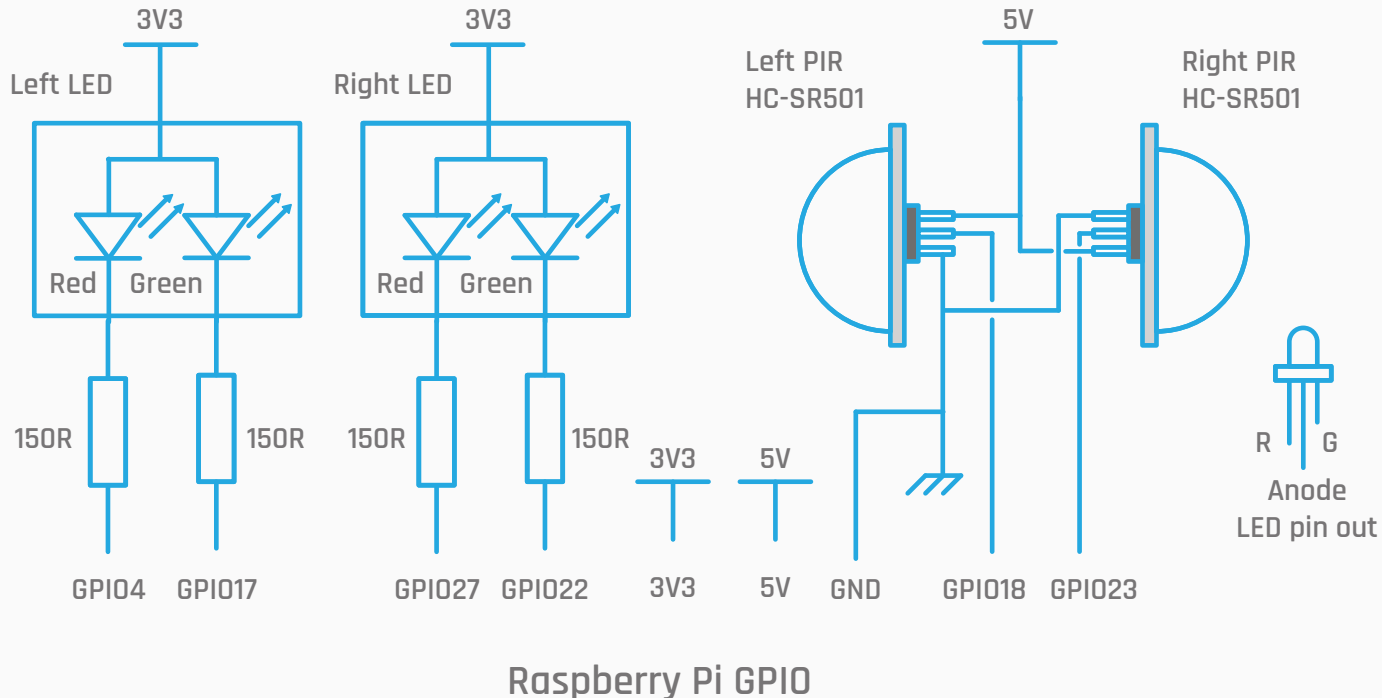


Fig 1 The circuit diagrams for the project

pull-up resistors. The indicator for each side is a red/green LED of the common anode type. This means to turn it on, the GPIO pin is set to zero. Using a 150Ω resistor gives 10mA through each LED, which is quite bright enough. The full schematic is shown in **Fig 1**; see the step-by-step section for details of construction. Note that when powering up, it takes about a minute before the sensors respond, as they have to auto-calibrate.

The game

The game is split into four phases:

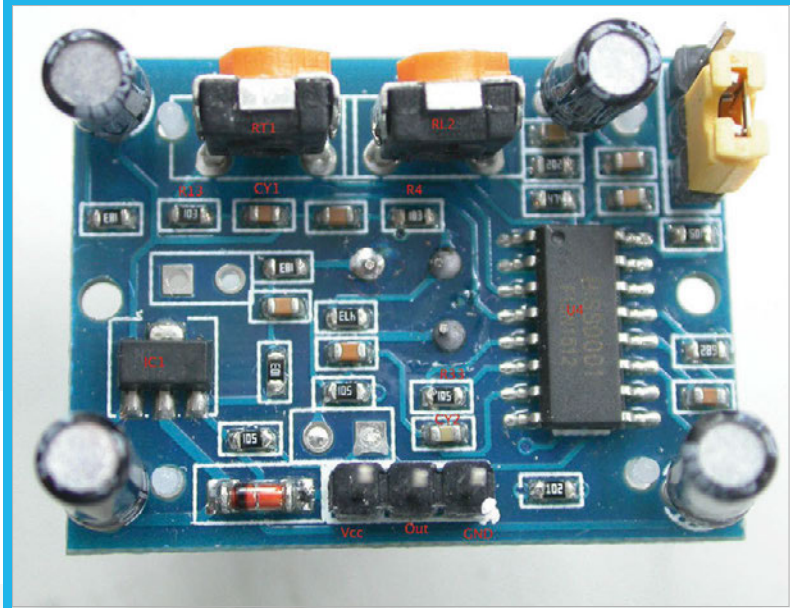
1) SETUP – the sensors wait until there has been no movement on either side for a time given by the **`startDelay`** variable. When this occurs, the music starts and the game progresses to the next phase.

2) RUNNING – the movement sensors are monitored, the music is looped if the file has ended, and the LEDs show movement, until the time in the **`playDuration`** variable is exceeded and the music stops. Then the game progresses to the next phase.

3) WINNER – when the time for the players to freeze, given in the **`stopDelay`** variable, has expired, the sensors are monitored to see who moves first. The winner is then displayed and the winner's LED is lit up yellow. After a small delay, the game progresses to the last phase.

4) RESTART – the game will halt until the computer operator presses the space bar. The game now goes back to the first phase.

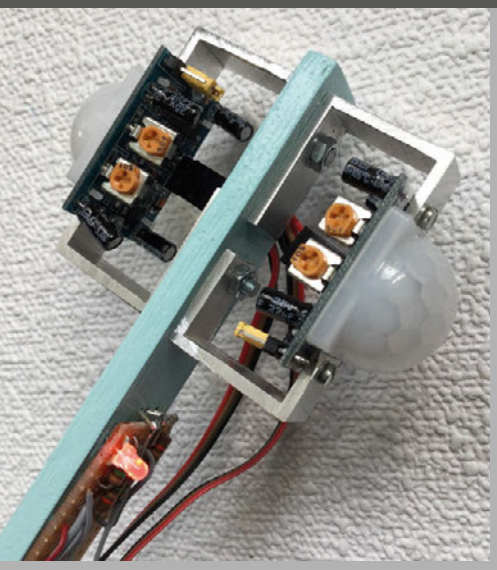
BUILDING THE STATUES CONTROLLER



>STEP-01

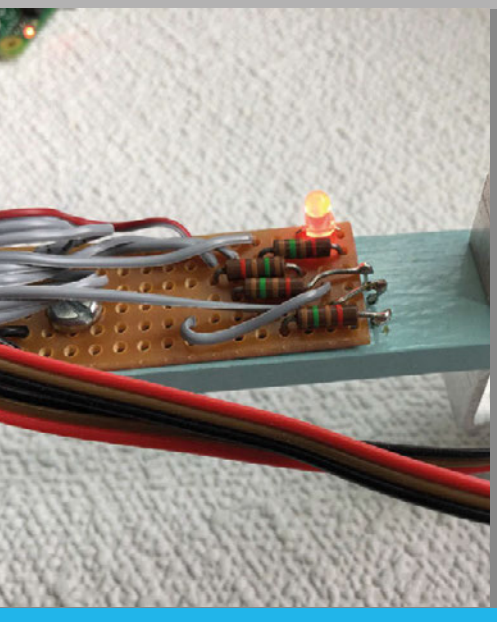
Modify the sensors

Locate capacitor CY1, under the pot delay RT1; and CY2, just above the ground pin. Remove them by quickly alternating your soldering iron from one end to the other until both ends melt and you can flick it off or grab it with tweezers. Clean the pads with some solder braid to remove all the solder; work quickly so you do not lift the pads. Then replace them with a 1nF to 1.5nF capacitor– we used a 1.2nF. Cut a 30mm length of 18mm by 6mm strip pine for the mounting stick and paint it if you like.



>STEP-02
Make the PIR mounts

Make four brackets 11mm wide from 2mm thick asymmetric aluminium channel 12mm by 24mm by 24mm. Drill 2mm holes in the short side to fix the PIR sensor to the bracket with an M2 nut and bolt. Cut the long side of two brackets down to 18mm so they do not overlap when attached to the sensor. Drill a 3mm hole in each long side so you can fix it to the stick with M3 nuts and bolts. Make sure the brackets do not foul any of the PCB tracks; assembly can be fiddly and a miniature spanner helps.



>STEP-03
Add the electronics

The few electronic parts fit on a piece of 6 by 24 hole stripboard, the copper strips running along the short side. Drill three 1mm holes through the stick to allow the LED to be mounted on the other side. Wire the power and signal connectors of the PIR sensors through a three-pin header socket to the board. Then wire it all back to the Raspberry Pi through a length of 9-way ribbon cable. Attach the ribbon cable to the stick with double-sided sticky foam pads, and make a 30mm bracket from 25mm by 15mm asymmetric aluminium angle and fix it to an MDF board about 100mm by 200mm.

The software

The **statues.py** program is written as a state machine following the game phases. The stages of the game are displayed in a small window and simply display an image consisting of the words/instructions for the current phase of the game. It uses the Pygame framework and the streaming music function to make sure that the music continues at the same point for the next round when the game resumes.

Taking it further

We recommend the game is played as a 'best of three and you are out' mode, but there is no software to enforce that, so you might like to add some, or even keep a score of the rounds won by each player. It is best played at one end of a room, but you might have to put some sort of a screen in front of the sensors to stop any movement from the audience interfering with them. You can replace the tune played with your own; the tune in the GitHub repository is one we wrote here at the Bakery – it might be a bit techno for some.

statues.py

```
01. #!/usr/bin/env python
02. # Statues
03.
04. import time, pygame
05. import os, sys, random
06. import wiringpi2 as io
07.
08. pygame.init()     # initialise pygame
09. os.environ['SDL_VIDEO_WINDOW_POS'] = 'center'
10. pygame.display.set_caption("Statues")
11. screen = pygame.display.set_
    mode([300,100],0,32)
12. pygame.mixer.quit()
13. pygame.mixer.init(frequency=22050, size=-16,
    channels=2, buffer=512)
14.
15. pygame.event.set_allowed(None)
16. pygame.event.set_allowed([pygame.
    KEYDOWN,pygame.QUIT])
17. moveSound = pygame.mixer.Sound("sounds/s0.ogg")
18. pygame.mixer.music.load("sounds/tune.wav")
19. pygame.mixer.music.set_volume(1.0)
20. pygame.mixer.music.play()
21. pygame.mixer.music.pause()
22. imageNames = ["ready","still","dance","freeze",
    "leftWin","rightWin","play"]
23. messages = [ pygame.image.
    load("images/"+imageNames[m]+".png")
24.              for m in range(0,7) ]
25.
26. setup = 0 ; running =1; winner = 2; rstart = 3
    # state machine constants
27. status = rstart # state machine status
28. stillTime = 0.0
29. startDelay = 2.0 # period to hold before game starts
30. stopDelay = 3.0 # period to wait after music
    # stops before looking at sensors
31. playDuration = 4.0 # time the music plays
32. restart = False
33.
34. def main():
35.    global leftMovement,rightMovement, status
36.    initGPIO()
37.    print"Statues game"
38.    print" Esc to quit"
39.    leftMovement = False
40.    rightMovement = False
41.    while True:
42.       checkForEvent()
43.       if status == setup:
44.          settingUp()
45.       if status == running :
46.          gameRun()
47.       if status == winner :
48.          gameWinner()
49.       if status == rstart :
50.          gameRstart()
51.
52. def settingUp():
53.    global stillTime, status, playTime
54.    checkSensors()
55.    showLEDs()
56.    if stillTime == 0:
57.       stillTime = time.time()
58.    elif time.time() - stillTime > startDelay :
59.       status = running
```

```
        playTime = time.time()
        pygame.mixer.music.unpause()
        #"play music - game running"
        displayMessage(2,128)
    if leftMovement or rightMovement:
        stillTime = 0
# reset the still time before the music
        moveSound.play()
        displayMessage(1,random.randint(40,220))

def gameRun():
    global leftMovement,rightMovement, status, playTime
    checkSensors()
    showLEDs()
    if time.time()-playTime > playDuration :
        #"music stops"
        displayMessage(3,128)
        pygame.mixer.music.pause()
        status = winner
        playTime = time.time()
    else :
        if not pygame.mixer.music.get_busy() :
        # check end of music file
            pygame.mixer.music.rewind()
            pygame.mixer.music.play()

def gameWinner():
    global leftMovement,rightMovement, status
    if time.time() - playTime > stopDelay :
        checkSensors()
        showLEDs()
        if leftMovement or rightMovement :
            moveSound.play()
            if leftMovement :
                print"right player wins"
                winLED(1)
                displayMessage(5,128)
            else :
                print"left player wins"
                winLED(0)
                displayMessage(4,128)
            status = rstart
            time.sleep(3.5)

def gameRstart():
    global restart, status, stillTime, playDuration
    if restart :
        restart = False
        status = setup
        checkSensors()
        showLEDs()
        displayMessage(0,128)
        print"ready"
        stillTime = 0.0
        playDuration = random.randint(6,20)+6
        # time till next stop
    else :
        displayMessage(6,128)

def winLED(player):
    for i in range(0,4): # all LEDs off
        io.digitalWrite(ledPins[i],1)
    if player == 0: # winner's LEDs yellow
        io.digitalWrite(ledPins[0],0)
        io.digitalWrite(ledPins[1],0)
    else  :
        io.digitalWrite(ledPins[2],0)
        io.digitalWrite(ledPins[3],0)

def displayMessage(m,b):
    pygame.draw.rect(screen,(
b,b,b),(0,0,300,100),0)
    screen.blit(messages[m],(0,0))
    pygame.display.update()

def checkSensors():
    global
leftMovement,rightMovement
    if io.digitalRead(pirPins[0])
== 1 and not(leftMovement):
        leftMovement = True
    elif  io.digitalRead(
pirPins[0]) == 0 and leftMovement:
        leftMovement = False
    if io.digitalRead(
pirPins[1]) == 1 and not(rightMovement):
        rightMovement = True
    elif io.digitalRead(pirPins[1]) == 0 and rightMovement:
        rightMovement = False

def showLEDs():
    if leftMovement :
        io.digitalWrite(ledPins[0],0) # turn Red on
        io.digitalWrite(ledPins[1],1) # turn Green off
    else :
        io.digitalWrite(ledPins[0],1) # turn Red off
        io.digitalWrite(ledPins[1],0) # turn Green on
    if rightMovement :
        io.digitalWrite(ledPins[2],0) # turn Red on
        io.digitalWrite(ledPins[3],1) # turn Green off
    else :
        io.digitalWrite(ledPins[2],1) # turn Red off
        io.digitalWrite(ledPins[3],0) # turn Green on

def initGPIO():
    global ledPins,pirPins
    ledPins = [ 4,17,27,22] # left R, left G, right R, right G
    pirPins = [18,23] # left / right
    try :
        io.wiringPiSetupGpio()
    except :
        print"start IDLE with 'gksudo idle' from command line"
        os._exit(1)
    for pin in range (0,4):
        io.pinMode(ledPins[pin],1) # led pin to output
        io.digitalWrite(ledPins[pin],1) # turn off
    io.pinMode(pirPins[0],0) # input left PIR sensor
    io.pinMode(pirPins[1],0) # input right PIR sensor
    io.pullUpDnControl(pirPins[0],2) # input enable pull up
    io.pullUpDnControl(pirPins[1],2) # input enable pull up

def terminate(): # close down the program
    print"closing down"
    pygame.mixer.quit()
    pygame.quit() # close pygame
    os._exit(1)

def checkForEvent(): # see if we need to quit
    global restart
    event = pygame.event.poll()
    if event.type == pygame.QUIT :
        terminate()
    if event.type == pygame.KEYDOWN :
        if event.key == pygame.K_ESCAPE :
            terminate()
        if event.key == pygame.K_SPACE :
            restart = True

if __name__ == '__main__':
    main()
```

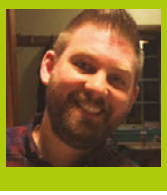
Language

>PYTHON

DOWNLOAD:
magpi.cc/1NqJjmV

PROJECT VIDEOS

Check out Mike's Bakery videos at:
magpi.cc/1NqJnTz



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@RaspberryCoulis

BUILD YOUR OWN RASPCADE: SOFTWARE

In the final part of our build, we'll be getting the software working so you can start playing with your RaspCade!

The RaspCade booting up, whilst displaying our custom splash screen
RaspCade
RASPCADE
This USB port makes adding new game ROMs a breeze!

You'll Need

- Class 10 micro SD card (16GB upwards recommended)
- RetroPie **magpi.cc/25UDXzh**
- USB flash drive (optional)
- Our custom splash screen **magpi.cc/2dFLR9N**

Now that we have finally assembled our RaspCade, the last part of this build is to get the software up and running so that we can start playing retro video games to our heart's content! Today, we'll be looking at how to install RetroPie, configuring your controls, adding your games, and any other tweaks to get the most out of our RaspCade so that you can play your favourite games whenever you feel like it!

>STEP-01

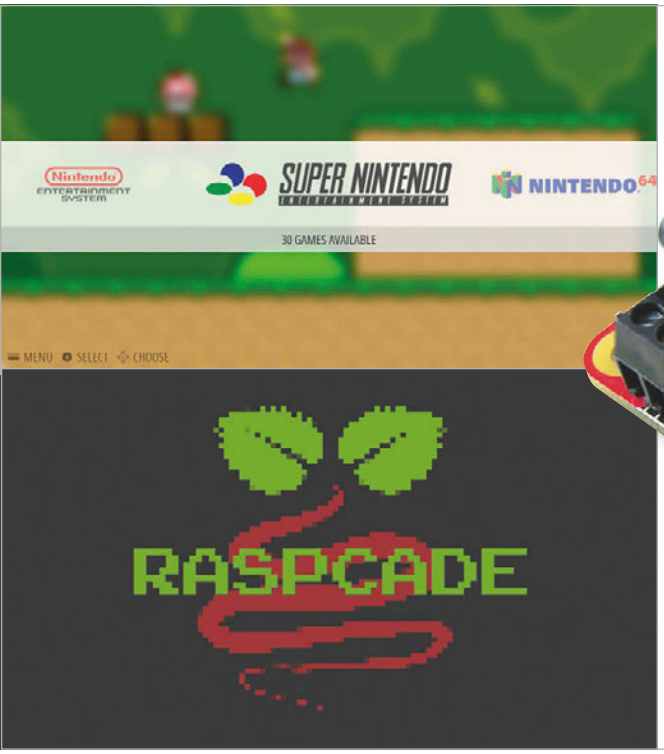
Download RetroPie

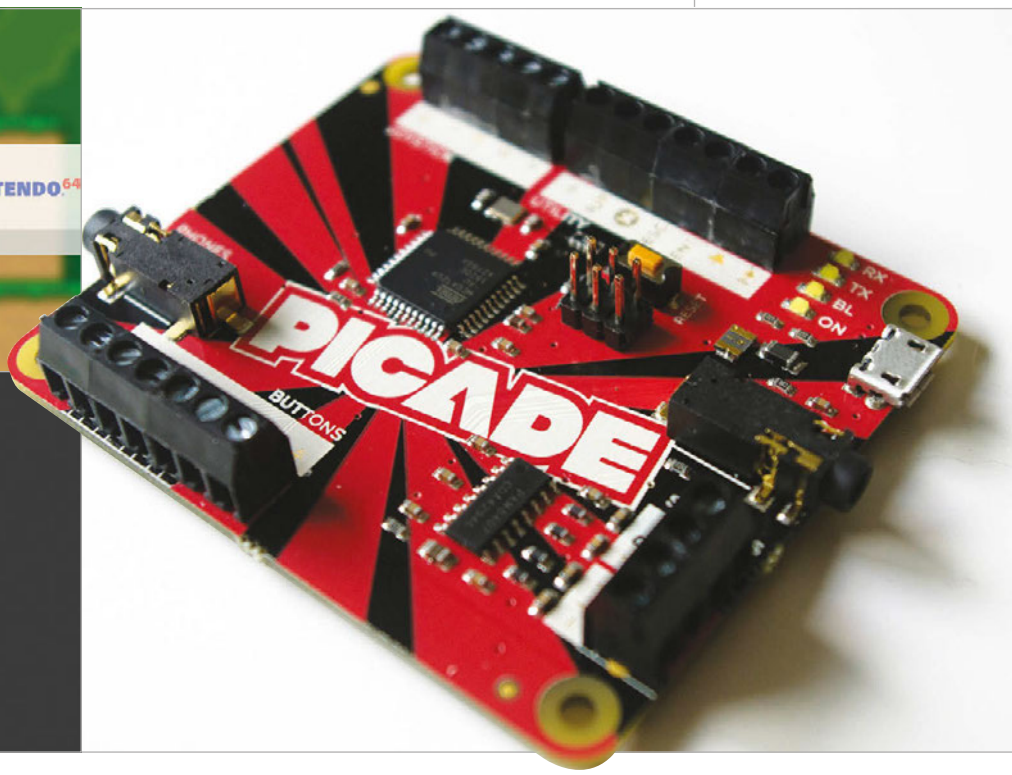
RetroPie plays a key part in our RaspCade, so head over to their website (**magpi.cc/25UDXzh**) and download the SD card image. Be sure to download the correct one for the Pi model that you're using, although we do recommend using the Pi 3 for this to get the most out of your RaspCade. For those of you who are unfamiliar with RetroPie, it's a fantastic piece of software that runs various video game emulators, but all within a beautiful user interface that closely matches today's generation of consoles. It's actively developed, and updates are pretty regular!

>STEP-02

Write your SD card

Now you have your SD card image, you can write this to your SD card using your preferred software. Check out Raspberry Pi's official documentation on how to do this (**magpi.cc/1V5Oj8E**). We do recommend investing in a quality SD card here; a Class 10 card is essential, as it will provide fast read and write speeds. The card will also need a decent amount of storage space if you want to store your ROMs on it; we would recommend at least 16GB of space for this, but up to 32GB is supported.





Above We highly recommend using Pimoroni's Picade PCB as it takes the hassle out of your controls and sound – a definite must!

>STEP-03

Boot your RaspCade

Once your SD card has been prepared, it's now time to pop this into your Pi and boot up your RaspCade! All being well, you should see the RetroPie logo as your RaspCade boots. You can use our custom RaspCade splash screen (**magpi.cc/2dFLR9N**) if you like and we'll cover how to change this shortly. The first boot usually takes a little longer than normal, as the file system will be expanded to fill your SD card, but you'll know when it's done when you see the welcome screen.

>STEP-04

Setting up your controls

Fortunately, RetroPie makes setting up your controls a simple process; you're asked to do this during the first boot. You should now see the welcome screen asking you to hold a button on your device to configure it. Press and hold one of the buttons on your RaspCade and then follow the on-screen prompts, pressing the relevant buttons when needed. You can skip assigning a button by holding any button until the tutorial moves on. All being well, you should be able to assign directions to your joystick, as well as the eight arcade buttons.

Above Whilst not in this guide for simplicity, putting NeoPixels inside the buttons adds some pizazz to the RaspCade

>STEP-05

Transferring your ROMs

ROMs, short for Read-Only Memory, are the game files. These are basically a collection of the files you'd find on a game cartridge if you took the data straight off them, and you'll need them play certain games on your RaspCade. The quickest way of transferring the ROMs to your RaspCade is by following the USB guide on RetroPie's website (**magpi.cc/2dmE14h**), as this will automatically transfer all the files to the correct place without any major user input. You can use the USB port on the front of the RaspCade to do this, too!

>STEP-06

Restart and play!

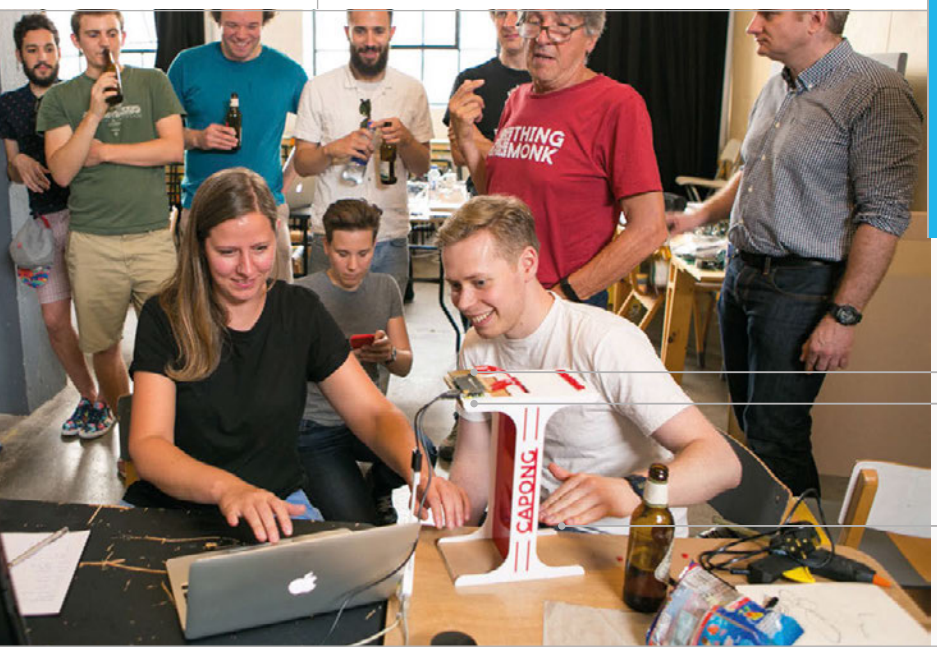
Once you have added all your ROMs, you need to restart your RaspCade so that RetroPie can load them. You should notice that different gaming systems will appear after you have rebooted, mirroring those that you've added. Now you can simply pick your system, choose your favourite game, and start playing on your very own RaspCade! You may need to tweak a few more settings, such as the display and controls for different systems, but we recommend getting to know the RetroPie wiki page (**magpi.cc/2emU7fV**) as there's a wealth of information there.

CUSTOM RASPCADE SPLASH SCREEN

Use our custom RaspCade splash screen by following the guide here (**magpi.cc/2emUokJ**) to complete the look!

ROMS ON USB INSTEAD

Use a USB flash drive to store your ROMs instead of the SD card by following the guide here for easier transfers: **magpi.cc/2emUxmK**



Four of the Pi Cap's 12 capacitive electrodes are being used as proximity sensors

The game runs on a Pi Zero with a Pi Cap add-on and Ethernet cable

Players move their hands between the Electric Paint sensors to control the paddles on screen

PAUL TANNER, ROSS ATKIN & TINA ASPIALA

Paul, Ross, and Tina are IoT developers, engineers, and designers. They enjoy testing the limits of the latest tech with Bare Conductive.

magpi.cc/2dDDdXP / @BareConductive

You'll Need

- Pi Cap and Electric Paint **magpi.cc/2e8kmGK**
- micro-USB cable
- Pi power supply
- Crocodile clips
- Acrylic
- Glue
- Cardboard
- Aluminium foil

CAPONG
A PONG GAME

Make a physical version of Pong! Use capacitive sensing and Electric Paint to make a fun and addictive two-player game to play with your friends

Capong breaks Pong out of the screen and into your hands. Map the Pong paddles to the position of your hands, using a Pi Cap and Raspberry Pi, to create a simple and addictive game. Capong is a physical reinterpretation of the original video game. Instead of mouse or arrow keys, it uses sensors arranged on a laser-cut stand so that each player moves her hand between a pair of sensors. The game is based on SimplePong, available on **openprocessing.org** and released under Creative Commons. It was modified to use input from the Pi Cap sensors and converted to two-player operation.

CROCODILE CLIPS

Make sure you leave enough length for each crocodile clip to reach its designated electrode.

First steps

First, we need to set up the Pi Cap. Run through the 'Setting up your Pi Cap on the Raspberry Pi Zero' tutorial found at **magpi.cc/2emLB1K**, and don't miss any steps. (You need to know the IP of the Pi to log into it.) Run through the Pi Cap intro to see the code examples, particularly the one that streams the sensor data via OSC to your laptop terminal window. Notice the DIFF data; that's what we'll be using.

Once you've done this, download and install Processing if that's not already on your laptop. Unzip and install the code **mpr121_pong** in Processing's sketch folder, usually **/Documents/Processing**. Open the sketch in Processing and start it running. To run the OSC demo standalone, go to your **PiCapExamples** folder on the Pi and **cd** to **cpp/picap-datastream-osc-cpp**. Use **`./run`** to see the Pi Cap datastream. Find out the IP of your laptop then use **`./run -host [IP address of laptop]`** to stream it to Processing. Pong should now be running. Click the laptop mouse to start a game; it finishes when a player misses the ball. Click the laptop mouse to start another game.

If you want to build the acrylic stand, as seen in our version, you can download the Illustrator files online (here: **magpi.cc/2enaB7V** and here: **magpi.cc/2enc6Tn**) and follow the tutorial instructions, courtesy of **@rossatkin**. You will need a laser cutter to cut these out, or you can make it out of foam board.

To assemble your stand, glue one of the I-shaped pieces of acrylic to the white rectangular piece with no holes in it.

To build the acrylic stand seen here, you can download the Illustrator files online

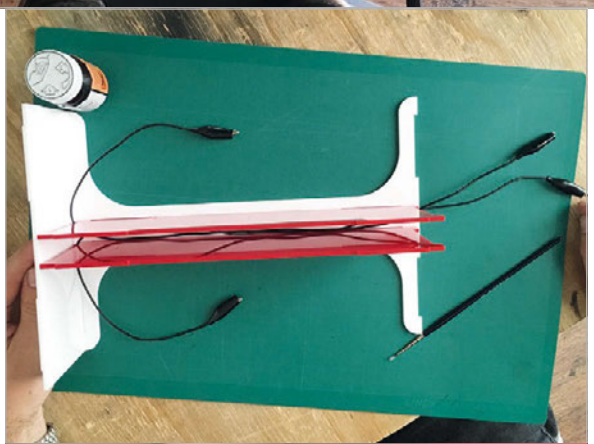
Before you glue in the two red rectangular pieces, make sure to insert two of the crocodile clips inside the structure; there should be a slot for the cables to exit when you attach the sides. This will ensure the wires are concealed within your stand, but still accessible.

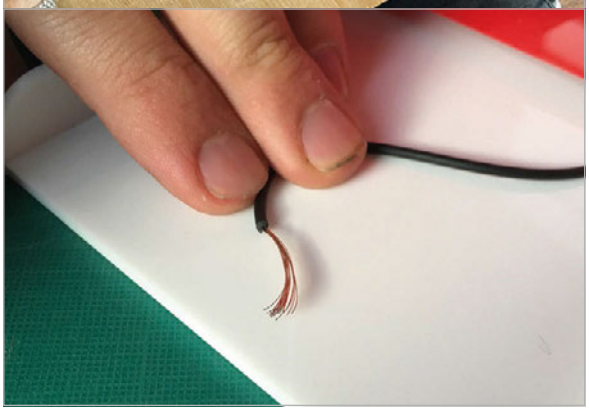
Glue the two red rectangular pieces to the white structure. Using a small paintbrush, dab all the joints of the stand with the acrylic glue; this adhesive will melt the plastic pieces together. Careful with the red acrylic: it may melt and release some colour. You should still have one acrylic piece remaining: the white rectangle with two holes. Don't glue this piece on yet.

Stand your Capong upright, so the white piece with no holes is touching the tabletop. Make sure you have enough wire so that your crocodile clips protrude at the top; you need at least 7.5cm of croc clip visible, as shown in the picture.

Now, leave some length of the wire out the bottom of the stand, and cut and strip the wire. You should have about 1.5cm of copper wire protruding. You're going to use this to attach the copper wire to the sensors.

Cut out two cardboard squares and two rectangles. These will go on your stand so you can measure the





Left Be patient with the build and you'll get there

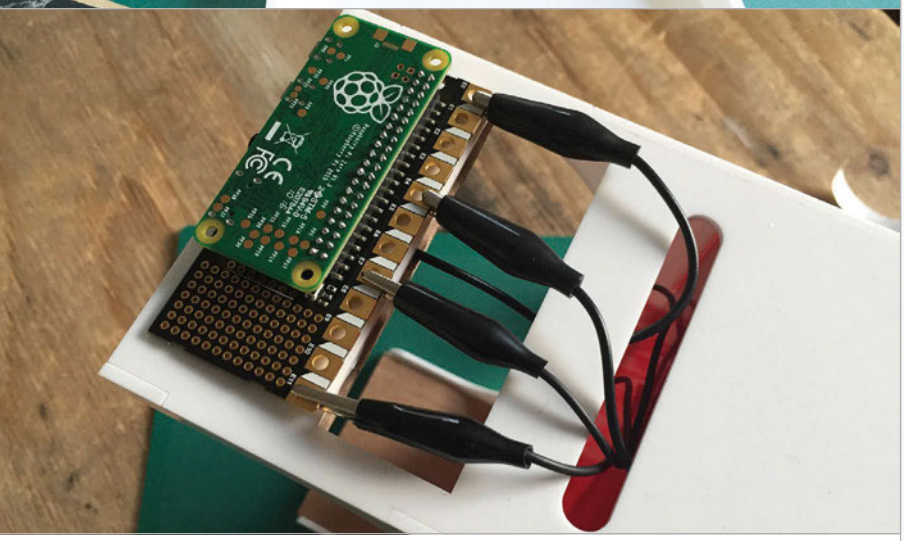
Bottom left You may need to shorten your crocodile clips during construction

RED ACRYLIC

Careful when gluing the red acrylic – it may melt and release some colour.

STRAIN RELIEF

Secure each cable on its sensor so they don't move (you can use double-sided tape).



Above top Paint Electric Paint to make your sensor, and to cold-solder to your crocodile clip

Above Attach each of the four crocodile clips from each sensor to the correct electrode

size of the interior surfaces. If you're using Electric Paint, you can paint directly onto these squares.

Once dry, apply some double-sided tape; you're going to glue the sensors face down against the acrylic. But first, you must cold-solder the paint!

Using your Electric Paint tube, squeeze out a generous amount of paint onto the exposed copper. You should make sure the wire is held in place so that it doesn't move around; you can use double-sided tape. When you're finished, you should have four sensors – two square, two rectangular – connected to each of the sides of the Capong stand.

If you don't have Electric Paint, you can make your sensors using aluminium foil. Just follow the same steps as above, but sandwich the exposed wire between the aluminium foil and the cardboard.

You can now firmly attach your sensors to the stand and get out your Pi Cap and Pi Zero. Take the crocodile clips that are protruding from the top of the Capong stand and attach them to your Pi Cap's electrodes. Make sure you're connecting to the correct electrodes, the ones you've programmed for functionality.

Now you can connect your Pi Zero, upload the code, and get playing!

TROUBLE-SHOOTING

Make sure you've mapped the correct crocodile clip to each sensor and electrode combination.

mpr121_pong.pde

```
01. import oscP5.*;
02. import netP5.*;
03.
04. final int numElectrodes  = 12;
05.
06. boolean serialSelected = false;
07. boolean oscSelected    = false;
08. boolean firstRead      = true;
09. boolean soloMode       = false;
10.
11. boolean gameStart = false; //true;
12.
13. float x = 150;
14. float y = 150;
15. float speedX = random(3, 5);
16. float speedY = random(3, 5);
17. int leftColor = 128;
18. int rightColor = 128;
19. int diam;
20. int rectSize = 150;
21. float diamHit;
22. int vpos1 = 0;
23. int vpos2 = 0;
24.
25.
26. OscP5 oscP5;
27.
28. int[] diffs;
29.
30. int globalGraphPtr  = 0;
31. int electrodeNumber = 0;
32. int serialNumber    = 4;
33. int lastMillis      = 0;
34.
35. void setup() {
36.   size(500, 500);
37.   noStroke();
38.   smooth();
39.
40.   // setup OSC receiver on port 3000
41.   oscP5 = new OscP5(this, 3000);
42.
43.   // other setup
44.   diffs = new int[numElectrodes];
45. }
46.
47. void oscEvent(OscMessage oscMessage) {
48.   println("oscevent");
49.
50.   if (firstRead && oscMessage.
51.         checkAddrPattern("/diff")) {
        firstRead = false;
52.   }
53.   else {
```

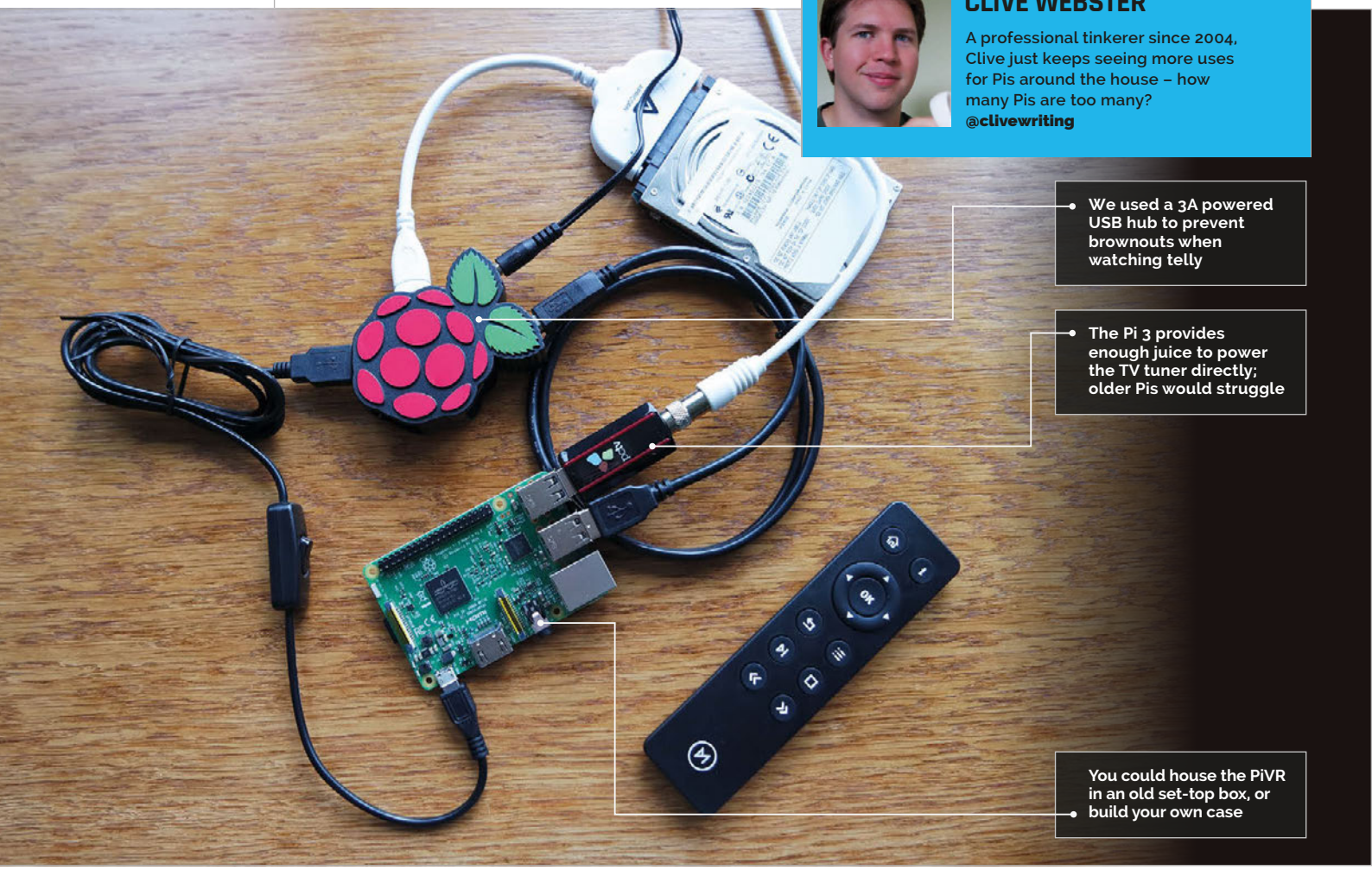
Language
>PROCESSING

DOWNLOAD:
magpi.cc/2dDE4bo

```
    if (oscMessage.checkAddrPattern("/diff")) {
      // simulate mouse in original game
      updateArrayOSC(diffs, oscMessage.
                arguments());
      vpos1=diffs[10]-diffs[1]+100; // guesswork
      vpos1*=2.5;
      if (vpos1 > 450) vpos1=450;    // limits
      if (vpos1 < 80) vpos1=80;
      vpos2=diffs[0]-diffs[11]+100; // guesswork
      vpos2*=2.0;
      if (vpos2 > 450) vpos2=450;    // limits
      if (vpos2 < 80) vpos2=80;
      print(vpos1, vpos2);
      println();
    }
  }
}

void draw() {
  background(255);

  fill(200,0,0);
  diam = 20;
  ellipse(x, y, diam, diam);

  fill(200,0,0);
  rect(width-30, vpos1-rectSize/2, 10, rectSize);
  rect(30, vpos2-rectSize/2, 10, rectSize);

    if (gameStart) {

    x = x + speedX;
    y = y + speedY;

    // if ball hits movable bar, invert X
       direction and apply effects
    if ( x > width-30 && x < width-20 && y >
              vpos1-rectSize/2 && y <
              vpos1+rectSize/2 ) {
      speedX = speedX * -1;
      x = x + speedX;
      rightColor = 0;
      fill(200,0,0);
      diamHit = random(75,150);
      ellipse(x,y,diamHit,diamHit);
      rectSize = rectSize-10;
      rectSize = constrain(rectSize, 10,150);
    }

    // similar if ball hits the other movable bar
       (2 players)
    else if ( x > 20 && x < 30 && y > vpos2-
       rectSize/2 && y < vpos2+rectSize/2 ) {
      speedX = speedX * -1;
      x = x + speedX;
      rightColor = 0;
      fill(200,0,0);
      diamHit = random(75,150);
      ellipse(x,y,diamHit
                ,diamHit);
      rectSize = rectSize-10;
      rectSize =
constrain(rectSize, 10,150);
    }

    // if ball hits wall, change direction of X
              (single-player only)
    else if (false && x < 25) {
      speedX = speedX * -1.1;
      x = x + speedX;
      leftColor = 0;
    }

    else {
      leftColor = 128;
      rightColor = 128;
    }

    // resets things if ball hits either wall - you lose
    if (x > width || x < 0) {
      gameStart = false;
      //delay(5000);  // auto-restart
      //gameStart = true;
      x = 150;
      y = 150;
      speedX = random(3, 5);
      speedY = random(3, 5);
      rectSize = 150;
    }

    // if ball hits up or down, change direction of Y
    if ( y > height || y < 0 ) {
      speedY = speedY * -1;
      y = y + speedY;
    }
  }
}

void mousePressed() {
  gameStart = !gameStart;
}

void updateArrayOSC(int[] array, Object[] data) {
  if (array == null || data == null) {
    return;
  }

  for (int i = 0; i < min(array.length,
              data.length); i++) {
    array[i] = (int)data[i];
  }
}
```

CLIVE WEBSTER

A professional tinkerer since 2004, Clive just keeps seeing more uses for Pis around the house – how many Pis are too many?
@clivewriting


We used a 3A powered USB hub to prevent brownouts when watching telly
The Pi 3 provides enough juice to power the TV tuner directly; older Pis would struggle
You could house the PiVR in an old set-top box, or build your own case

You'll Need

- USB TV tuner **linuxtv.org/wiki**
- USB remote control **magpi.cc/2dDLriE**
- USB hard disk **magpi.cc/2dDLN8F**
- Powered USB hub **magpi.cc/2dDLFGh**
- OSMC **osmc.tv**
- MPEG2 codec **magpi.cc/2dDLToc**

PiVR

A PI-POWERED PVR

Make your own PVR to record and watch live TV, as well as stream video and audio

The secular festival of Good Telly Season is just around the corner, so what better time to make a PVR that does everything? From recording TV shows to streaming favourite films from your NAS to playing tunes from your smartphone, a PiVR can do everything apart from virtual reality: the name's a little misleading like that.

Better still, your PiVR only uses USB devices and requires a few fairly basic terminal commands to get running. There's nothing here to scare a Pi novice, and plenty to please the experts.

The PiVR is based around a Pi 3, both for its processing power and the current it can feed to USB devices. The TV tuner used in this project can be found here: **magpi.cc/2dDMTS7**. However, with this TV tuner taking up to 500mA, an old laptop hard disk sucking 1A and the Pi itself consuming up to 800mA, we worried about brownouts if we powered everything from the Pi. We therefore based our project around a 3A powered USB hub: plenty of headroom.

OSMC and the software

We chose OSMC (**osmc.tv**) as the basis for the PiTV, as it incorporates the popular Kodi front-end (albeit in skinned form) with a full Raspbian back-end. Essentially, it's easy to use and easy to modify and

add to. Better yet, it's a cinch to install: download the installer and it'll set up your SD card automatically. You can even enter your WiFi details during the install so the Pi is ready to go once it's booted.

Update OSMC and its apps in the usual way, over SSH. The login credentials are **osmc**/**osmc**: change these as soon as possible via the **passwd** command.

```
sudo apt-get update && sudo apt-get -y upgrade
```

If your hard disk has also lived a former life, wipe and format it with **fdisk** and then reboot.

```
fdisk /dev/sda
```

Next, mount the hard disk and link it to a folder called **recordings**:

```
sudo mkfs.ext4 /dev/sda -L storage
sudo mkdir /mnt/recordings
sudo mount /dev/sda /mnt/recordings
sudo chown osmc:osmc /mnt/recordings
sudo chmod 777 /mnt/recordings
```

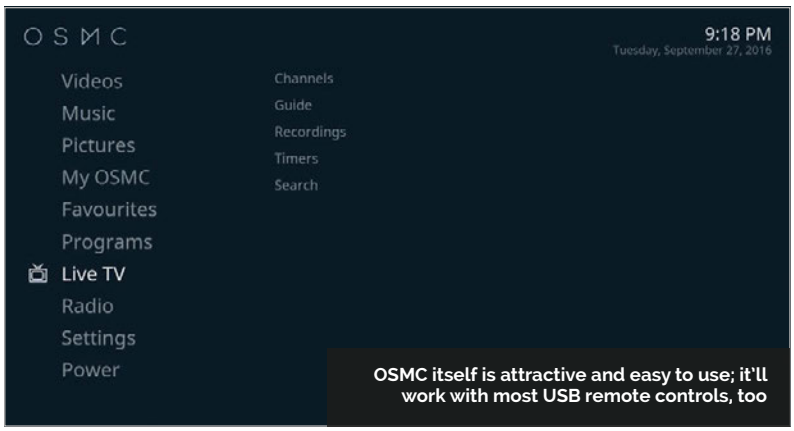
Now you can find your Pi's serial number, which is needed to buy an MPEG-2 codec licence for your Pi (this licence will be tethered to your Pi). Without an MPEG-2 codec licence, the Pi will have to decode the TV signal in software rather than its bespoke hardware, which can lead to overheating and general performance issues. Follow the instructions at **magpi.cc/2dDLToc** and pay the £2.40. Your licence code should arrive within 72 hours; add the entire line of the received MPEG-2 licence to your config file:

```
sudo nano /boot/config.txt
```

Getting your TV tuner up and running might require some detective work, but your first step is to find your tuner on **magpi.cc/2dDNsLv**. If you're lucky, your tuner won't require specific firmware, otherwise you'll have to download it, typically from GitHub: see **magpi.cc/2dDMI9h**. However, our PCTV TripleStick (292e) required even newer firmware, which we found at **magpi.cc/2dDMiQm**:

```
wget http://palosaari.fi/linux/v4l-dvb/
firmware/Si2168/Si2168-B40/4.0.25/dvb-demod-
        si2168-b40-01.fw
sudo mv dvb-demod-si2168-b40-01.fw /lib/firmware
sudo reboot
dmesg
```

The return from **dmesg** shouldn't list any errors regarding firmware not downloading. If so, you can proceed to setting up Tvheadend, the server and client combination that handles all the live TV duties for the PiVR.



OSMC itself is attractive and easy to use; it'll work with most USB remote controls, too

Tvheadend on OSMC

The easiest way to install the latest, correct version of Tvheadend is via OSMC's front-end. First, you must navigate its awkward setup procedure; use only a keyboard, as it's too easy to get confused as to which level of menu or option you're selecting with a mouse. Once negotiated, head to **My OSMC** and track across to **Remotes** to set up your remote. Then track back to the **OSMC Store** and install Tvheadend (it's free, don't worry), not forgetting to select **Apply** to actually start the installation.

Once installed, you'll need to switch to another computer to set up Tvheadend; point a browser to **http://<pi-ip-address>:9981** and log in with **osmc**/**osmc**. Now follow this setup order to avoid getting into awful tangles with Tvheadend. First, head to **Configuration > DVB Inputs > Networks**. Click **Add** and then choose DVB-T as the Type; on the next screen give your 'network' a relevant name and select the correct Predefined Mux for your TV area (see **digitaluk.co.uk** if you're not sure). If you're on the edge of two masts' coverage, add a network for both.

Now go to the **TV adapters** tab and select your TV tuner; on the right-hand pane, tick the Enabled box and add any and all networks via the Networks field. Head to the **Muxes** tab and you should see many entries with a scan status of PEND; after a while, these will switch to Active, and hopefully then to OK. The last job in the Tvheadend webpage is to head to the **Recording** tab and change the recording location to your hard disk, in our case **mnt/recordings**. Click **Save** which is toward the top-left for this section.

Now you can switch back to OSMC on your Pi. Head to **Settings > Add-ons > My add ons > PVR clients > Tvheadend HTSP Client**. Press **Enter** on your remote, then select Configure. Enter the Tvheadend login details (**osmc**/**osmc**) and then select Enable. Finally, head to **Settings > TV > General** and tick Enabled; you should see OSMC update a few things. Head back to the main OSMC menu and you'll now see an option for Live TV. Open that, and you'll see an EPG and other such options. To watch a show, select it from the EPG and then press **Back** on your remote until you go 'beyond' the main menu into full-screen live TV.

NEATER BUILD

Using a 314GB WD PiDrive (which only consumes 0.55A) might allow you to drop the USB hub from the build.

AUDIO ADD-ON

OSMC supports AirPlay (from iTunes servers) while the Pi 3 has Bluetooth – upgrade the audio output and you've got a streaming jukebox.

SCREEN OUT

Add a VFD display for extra slickness, perhaps using a £10 ZeroSeg with the two buttons left off (**magpi.cc/2dOtGBg**).

FREQUENTLY ASKED QUESTIONS

NEED A PROBLEM SOLVED?

Email **magpi@raspberrypi.org** or find us on **raspberrypi.org/forums** to feature in a future issue.

Your technical hardware and software problems solved...

RASPBERRY PI HATS

WHAT IS A HAT?

Add-on

A HAT is a type of add-on for the Raspberry Pi that connects to the GPIO pins and gives it further functionality. There's a specific definition that takes into account size and other factors, but that's the major part you need to know.

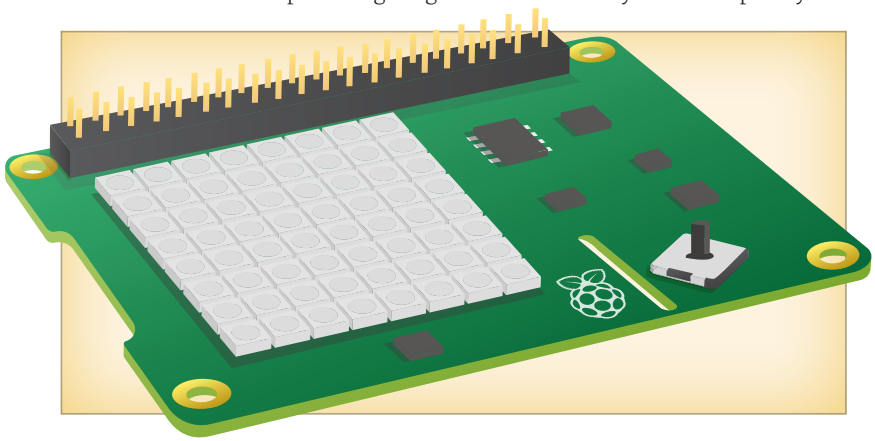
Hardware Attached on Top

HAT is an acronym (or possibly a backronym) of Hardware Attached on Top, as the hardware add-on is attached on top of the Raspberry Pi. Smaller HATs are sometimes called pHATs and are usually designed with the Pi Zero in mind.

Other add-ons

There are other add-ons for the Raspberry Pi that aren't called HATs; usually, they don't meet the 'HAT' specification mentioned earlier, but they're no less capable of giving extra functionality to the Raspberry Pi.

Below The Sense HAT is the official Raspberry Pi HAT, and it's used on the Astro Pi mission



TYPES OF HATS

Sensors

The Sense HAT is one of the most famous HATs; as well as adding a big LED matrix, it has extra sensors. This allows the Raspberry Pi to use humidity, temperature, and other measurements in programs.

More inputs

Some HATs can add extra buttons or input devices to the Raspberry Pi. The Skywriter HAT allows for motion controls, while the Piano HAT has capacitive piano keys you can use to create a symphony.

Extra ports

Not quite as common are HATs that add extra connectivity to the Pi. This can be alternate wireless or wired internet connections, extra USB ports, or even motor controllers to plug robot parts into the Raspberry Pi easily.

BUYING HATS

Official HATs

The Sense HAT is currently the only HAT officially made by Raspberry Pi; you can get it from a few places such as Pimoroni, Element14, and other official suppliers. Check out the page for it on the Raspberry Pi website for more information: **magpi.cc/1TGGUt5**

Unofficial HATs

These can be made by anyone and you'll find them either on general Raspberry Pi online stores for the more generic ones, or on specialist sites for the more niche varieties. Just because they're not made by Pi, though, doesn't make them any less of a HAT.

Make your own HAT

If there's a specific function you want to add to your Raspberry Pi, why not create your own special HAT? We did a tutorial on this in issue 42 of *The MagPi* (which you can find here: **magpi.cc/Issue-42**), so give it a look.

FROM THE RASPBERRY PI FAQ
RASPBERRYPI.ORG/HELP

What is the Camera Module?
The Camera Module is a small PCB that connects to the CSI-2 camera port on the Raspberry Pi using a short ribbon cable. It provides connectivity for a camera capable of capturing still images or video recordings. The camera connects to the Image System Pipeline (ISP) in the Raspberry Pi's SoC, where the incoming camera data is processed and eventually converted to an image or video on the SD card (or other storage). You can read more about the Camera Module here: **magpi.cc/28ljlsz**.

What model of camera does the Camera Module use?
The Camera Module V2 is a Sony IMX219, while the original Camera Module is an Omnivision 5647. They are comparable to cameras used in mobile phones.

What resolutions are supported?
The Camera Module V2 is capable of taking photos up to 8 megapixels (8MP). It supports 1080p30, 720p60 and VGA90 video modes, as well as still capture. The original Camera Module is capable of taking photos up to 5 megapixels and can record video at resolutions up to 1080p30.

Which picture formats are supported?
The Camera Module supports raw capturing (Bayer data direct from the sensor) or encoding as JPEG, PNG, GIF, BMP, uncompressed YUV, and uncompressed RGB photos. It can record video as H.264, baseline, main, and high-profile formats.

How do I use the camera?
There are three command-line applications provided for stills, video, and stills output uncompressed. These applications provide the typical features you might find on a compact camera, such as set image size, compression quality, exposure mode, and ISO. See the documentation for more details: **magpi.cc/2egdAQA**.

Can I extend the ribbon cable?
Yes. We have reports of people using cables up to 4 metres long and still receiving acceptable images, though your experience may differ.

THE MAGPI APP

Having trouble with *The MagPi* on the App Store or Google Play? Here are your most common questions answered:

How do I find *The MagPi* on Google Play or the App Store?
All you have to do is go to the search bar and type 'The MagPi' or 'Raspberry Pi' to find us.

I've subscribed to the digital edition and I can't sign in to restore my purchases. Please help!
Since your *The MagPi* purchases are linked to your Google or Apple accounts, there's no need to sign in at all. If you'd like to re-download your purchases on your current device, or make your purchases available on other devices, all you need to do is press 'Subscribe' on the home screen, then 'Restore Purchases' on the next screen.

How can I search the digital magazine for keywords?
Finding direct references is really easy with *The MagPi* app: all you have to do is tap the screen to get the app's GUI to show, and then press the small magnifying glass icon in the top-right corner of the screen. Just type in your search term to find the relevant results.

GET IT ON Google Play

Available on the App Store

HALLOWEEN PROJECTS MADE EASY

Not got much time before Halloween? Try out these quick and easy spooks to scare your friends

It's that time of year again. The nights are longer, the air is colder, and there's a faint cackling on the wind. It might be a witch, or it might just be a fox. Yes, it's Halloween, and by the time you read this, it's going to be very soon.

Fear not (or do, it's Halloween after all), as we've put together some quick and easy fang-tastic tutorials to help you spook up the place: a ghastly game where you dodge skeletons, a box that screams when you go near it, and a pumpkin lit by electricity instead of a flame.

Prepare yourselves, it's about to get spooky...

SKELETON DODGER 70

Can you survive a walk in the woods and avoid all the nasty skeletons in this Scratch game?

SCREAMER 72

Create a nasty surprise for anyone with this motion-activated screaming Pi.

LED-LIT PUMPKIN 74

Don't waste candles: create a spooky, electric-powered jack-o'-lantern instead.

ROB ZWETSLOOT

Tinkerer, sometime maker, other-times cosplayer, and all-the-time features editor of *The MagPi*.
magpi.cc / @TheMagP1

SKELETON DODGER

Create a spooky Scratch game and dodge those nasty skellies

You'll Need

- Scratch 2.0 **scratch.mit.edu**
- Game sprites **magpi.cc/SkeleDodger**
- Some willing friends

You should always be careful when walking through the woods around Halloween; what if a scary skeleton has a bone to pick with you? In this tutorial we're making a simple game in Scratch, where you have to dodge the skeletons by pressing the left or right arrow on your keyboard in time. We're making this in Scratch 2.0 in the new Raspbian with PIXEL Chromium browser; refer to the tutorial starting on page 46 for how to get it ready.

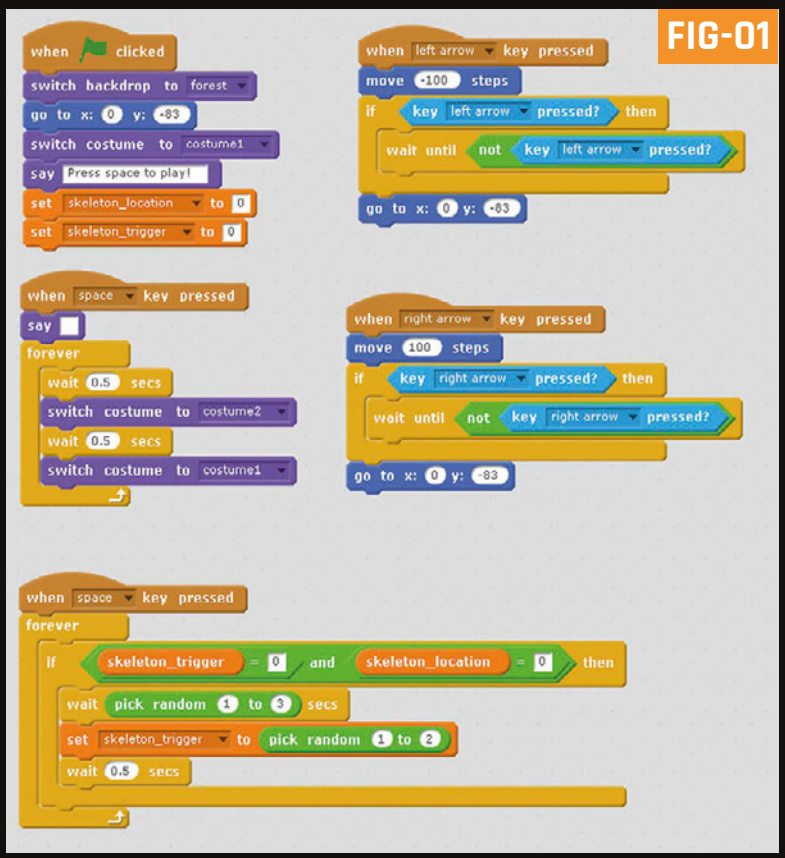


FIG-01
when clicked
switch backdrop to forest
go to x: 0 y: -83
switch costume to costume1
say Press space to play!
set skeleton_location to 0
set skeleton_trigger to 0
when left arrow key pressed
move -100 steps
if key left arrow pressed? then
wait until not key left arrow pressed?
go to x: 0 y: -83
when space key pressed
say
forever
wait 0.5 secs
switch costume to costume2
wait 0.5 secs
switch costume to costume1
when right arrow key pressed
move 100 steps
if key right arrow pressed? then
wait until not key right arrow pressed?
go to x: 0 y: -83
when space key pressed
forever
if skeleton_trigger = 0 and skeleton_location = 0 then
wait pick random 1 to 3 secs
set skeleton_trigger to pick random 1 to 2
wait 0.5 secs

>STEP-01

Get some sprites

We've already pre-prepared some sprites that you can use for this artful game of bone avoidance, which you can find here: **magpi.cc/SkeleDodger**.

This includes an animated skeleton sprite, a pointer to warn you which direction a skeleton will come from, and a forest background. These were all obtained from **OpenGameArt.org**, an amazing place to get free graphics and sounds for your games.

Go to **scratch.mit.edu**, start a new project, and click on 'Upload backdrop from file' to upload the forest background. We also then moved the cat so it looked like it was walking along the ground.

>STEP-02

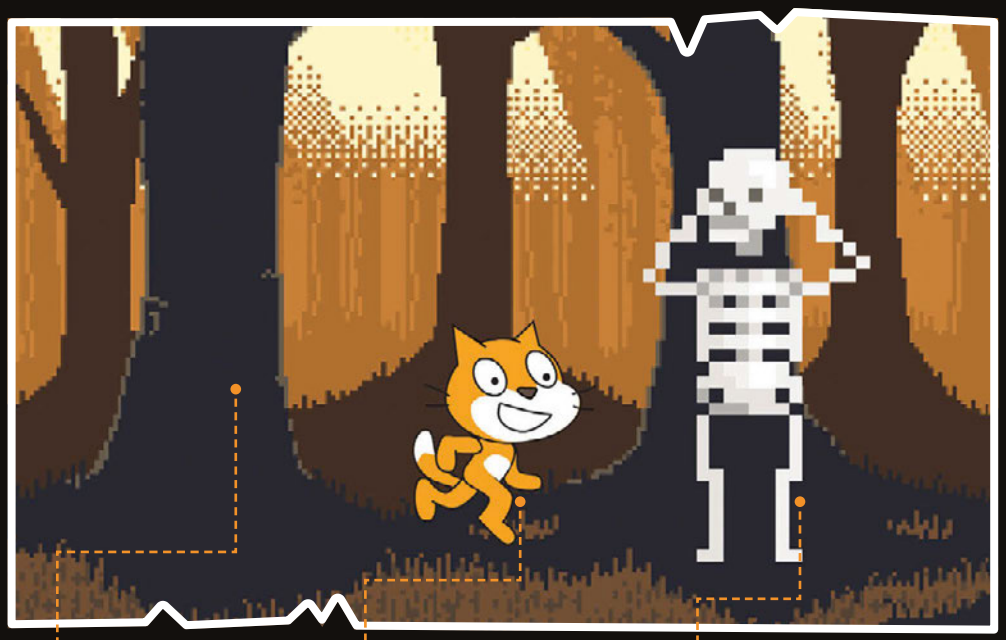
Different costumes

Load the **skele1** sprite into Scratch by clicking on 'Upload sprite from file' in the Sprites box. Place him on the left side of the screen for now. Click on the Costumes tab and click on the 'Upload costume from file' icon to upload the rest of the skeleton sprites. Once you've done that, click 'Paint new costume' to add one more sprite to the skeleton. Don't make anything; just save it and name it **skeleo**. This allows us to have the skeleton disappear! Now, upload the **pointer** sprite in the same way, and create a blank costume for it so we can have it blink.

>STEP-03

Cat code

See **Fig-01** for how we're coding the cat. When the green flag is pressed, the game is reset and the cat asks you to press the space bar to play. Pressing **SPACE** stops the cat's message, then starts a looping walking cycle using its second costume. **SPACE** also

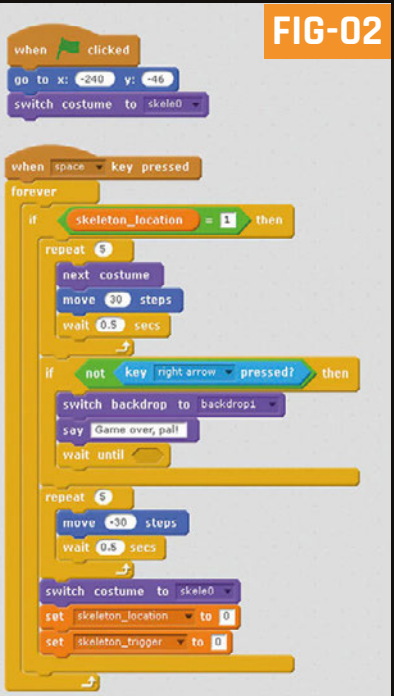


A spooky forest background for our very spooky game

The cat is you, walking through the forest, not a care in the world

The skeletons are out to get you! You'll get a warning where they're coming from

FIG-02



starts the countdown to the first skeleton appearing, which happens in one, two, or three seconds thanks to `pick random`. We then select a random skeleton using the `skeleton_trigger` variable. We can also move the cat left or right by holding down the keys on the keyboard; when you let go, he'll return to the centre.

>STEP-04

Pointer code

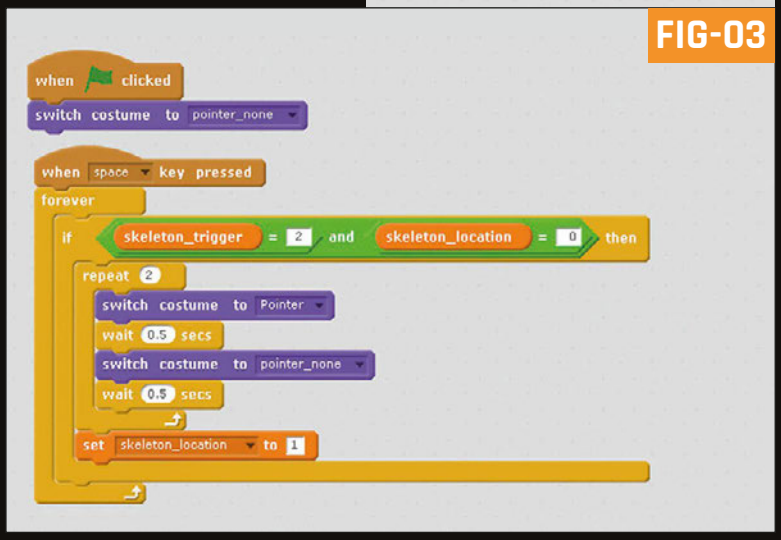
The pointer is quite simple, as seen in **Fig-02**. When it senses that the right `skeleton_trigger` has been activated, it will then flash for a few seconds to warn the player a skeleton is coming. It then calls a specific skeleton by setting the `skeleton_location` variable. You'll need to duplicate the point to have one on the other side; right-click and duplicate the sprite, click on the 'i' in the sprite box, select the left-right arrow in the rotation style, and flip it to -90 degrees. Copy the code to the new pointer; make sure to change the `skeleton_location` and `trigger` number around.

>STEP-05

Skeleton code

Fig-03 shows one of the skeleton's scripts – there's two of them, but they work the same way. They reset their position when the game starts, and then when **SPACE** is pressed, they wait until they're called at the end of the pointers script. They'll move towards you and then check to see if you're there or not. If you are, the game stops and then they tell you it's game over. If not, they move back, thwarted again by your fast reflexes. The script then resets the variables to start again. You'll need to create a second skeleton, just like we created a new pointer, with different parameters.

FIG-03



>STEP-06

Tweak it and get playing!

Play around with the positions of the cat, pointers, and skeletons, as well as the way they move, to perfect your version of Skeleton Dodger. There are many ways you can improve the game as well; why not add a score system to it? You can also set it up so you only move left or right for a short amount of time, meaning you have to time your press exactly. You can even make it so that game over occurs at different times. Get spooky and have fun!

CODE:

Scratch 2.0

magpi.cc/SkeleDodger

LUCY HATTERSLEY

Lucy is the news editor for *The MagPi*. When she's not chasing stories, she's creating random entertaining projects.
magpi.cc

CREATE A SCREAMER

Turn your Raspberry Pi into a motion-sensitive scream queen with our guide to mixing PIR sensors and audio files

You'll Need

- Wilhelm Scream audio file **magpi.cc/2diLoex**
- HC-SR501 PIR sensor **magpi.cc/2diJivg**
- Mini portable speaker **magpi.cc/2diQyHq**
- Breadboard and jumper wires

Halloween and screaming go hand in dismembered hand. So what better Halloween project than turning your Raspberry Pi into a motion-detecting screamer?

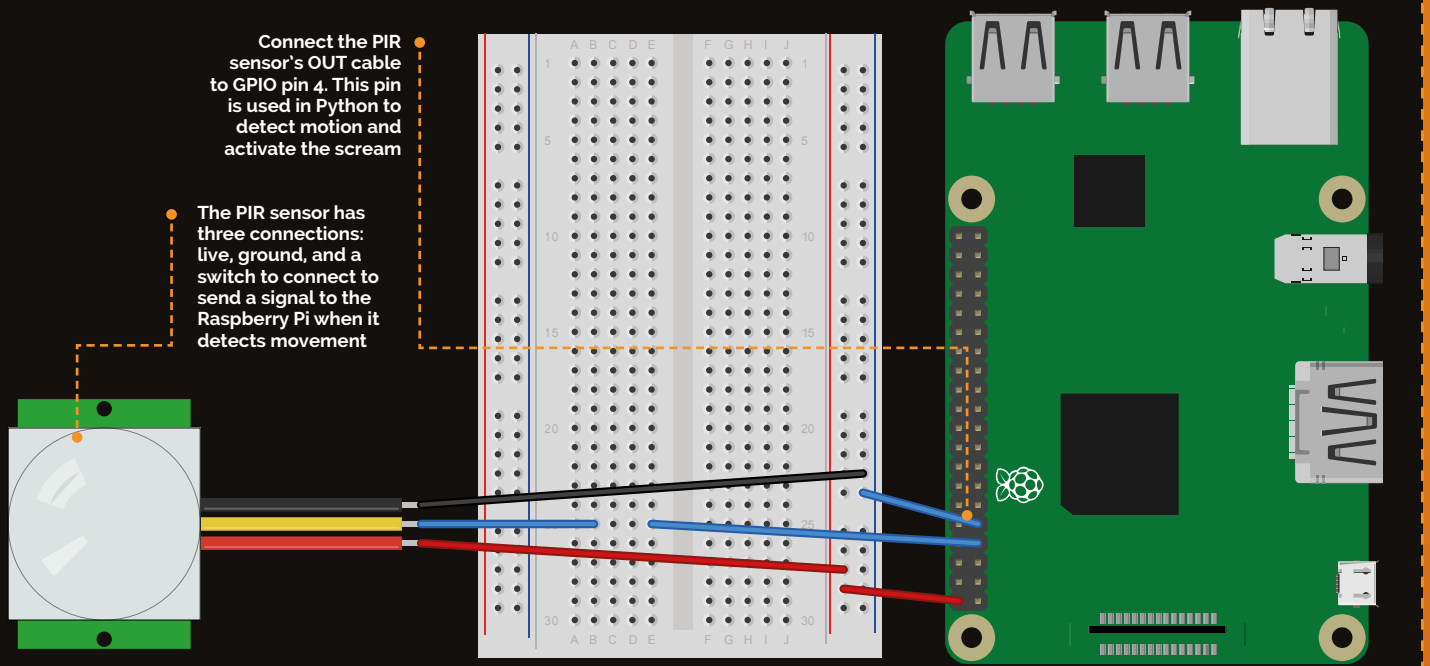
In this project we're going to use a PIR sensor to detect movement, then get our Raspberry Pi to play an audio file of a scream. Attach an amplified speaker to your Raspberry Pi, and you have a scream box you can hide around the home (or squeeze inside a pumpkin).

There are lots of famous screams, from Fay Wray in *King Kong* to William Shatner in *The Wrath of Khan*, or the Tarzan Yell. But we've picked the most famous of all: the Wilhelm Scream.

>STEP-01

Get the scream

Start by creating an empty folder to contain our code and files using `mkdir ~/screamer`. Now move into the folder using `cd ~/screamer`. Download the scream directly from Archive.org using `wget https://archive.org/download/WilhelmScreamSample/WilhelmScream.wav`. It's become a Hollywood joke to sneak the Wilhelm Scream into movies, and it's been in over 225 so far (including all *Star Wars* films, *Lord of The Rings*, and lots of Disney movies). You can watch a video compilation of Wilhelm Scream on YouTube (**magpi.cc/2diKSNB**).


Connect the PIR sensor's OUT cable to GPIO pin 4. This pin is used in Python to detect motion and activate the scream
The PIR sensor has three connections: live, ground, and a switch to connect to send a signal to the Raspberry Pi when it detects movement

scream.py

```
from gpiozero import MotionSensor
import time
import pygame

pygame.mixer.init()
pygame.mixer.music.load("WilhelmScream.wav")

pir = MotionSensor(4)

pir.wait_for_no_motion()

while True:
    print("Ready")
    pir.wait_for_motion()
    print("Motion detected")
    pygame.mixer.music.play()
    time.sleep(3)
```

Above With a portable charger it's possible to embed the Raspberry Pi inside a pumpkin. Just make sure the PIR sensor can view the outside. (image: Daryl Mitchel, Flickr)

>STEP-02
Attach PIR motion sensor

We need to wire the PIR (passive infrared) sensor to the Pi. While it could be hooked to the GPIO pins directly using female-to-female jumper wires, we're doing it via a breadboard. The sensor has three pins: VCC (voltage supply), OUT (output), and GND (ground). Use female-to-male jumpers to connect VCC to the '+' rail of the breadboard, and GND to the '–' rail. Wire OUT to a numbered row, then use another jumper to connect that row to GPIO pin 4.

>STEP-03
Connect the speaker

Connect a speaker to your Raspberry Pi using the audio output connector. You'll need to use active speakers with a separate power source, as the Raspberry Pi doesn't have enough power to drive passive speakers. Turn your speakers up nice and loud, so the scream will be effective. Enter **`aplay WilhelmScream.wav`** in the terminal to hear the scream in action.

>STEP-04
Open IDLE

Open IDLE using **Menu > Programming > Python 3 (IDLE)** and create a new file (**File > New File**). Save it as **scream.py** in the **screamer** directory you created in the first step. Now enter the code from the **scream.py** listing. First, we import **`MotionSensor`** from gpiozero, along with **`time`** and **`pygame`**. We're using Pygame for its audio support. Next, we initialise the mixer with **`pygame.mixer.init()`**. Finally, we load in the **WilhelmScream.wav** file. The audio file needs to be in the same directory as the **scream.py** program because we're using a relative path.

>STEP-05
Set up the sensor

Next, we create an object (called **`pir`**) in our code and connect it to GPIO pin 4. We do this using the gpiozero API with **`pir = MotionSensor(4)`**. Now we can call on the motion sensor using the **`pir`** object's methods. The first method we use is **`wait_for_no_motion()`**. This allows time for the PIR sensor to sleep when we first run the code, so our Raspberry Pi doesn't start screaming as soon as we run the program.

>STEP-06
Create the scream

Our code ends with a **`while True:`** block to create an infinite loop and keep our sensor running. Inside the loop we have a **`pir.wait_for_motion()`** function to get our sensor watching for movement. When it activates, we'll use the **`pygame.mixer.music.play()`** function to play the scream. Then we use **`time.sleep()`** to pause before scanning again. Use **`python scream.py`** in the terminal to run the program. Leave the room so the PIR sensor can settle down. Then re-enter and listen to your scream.

CODE:
Python
magpi.cc/2dA5G1K

ROB ZWETSLOOT

Tinkerer, sometime maker, other-times cosplayer, and all-the-time features editor of *The MagPi*.

magpi.cc / @TheMagPi

ELECTRIC-POWERED JACK-O'-LANTERN

Forget candles: power up your pumpkin with a flickering candle-effect LED

You'll Need

- LED (orange or red works)
- Resistor (400Ω)
- Wires and such (jumpers will do)
- Carved pumpkin (scary)

Putting an LED into a pumpkin is easy; Screamer over the page used a plastic one and that didn't even need a Raspberry Pi for it! However, you don't quite get that great candle flickering effect in the pumpkin, even if you're saving on burning through candles.

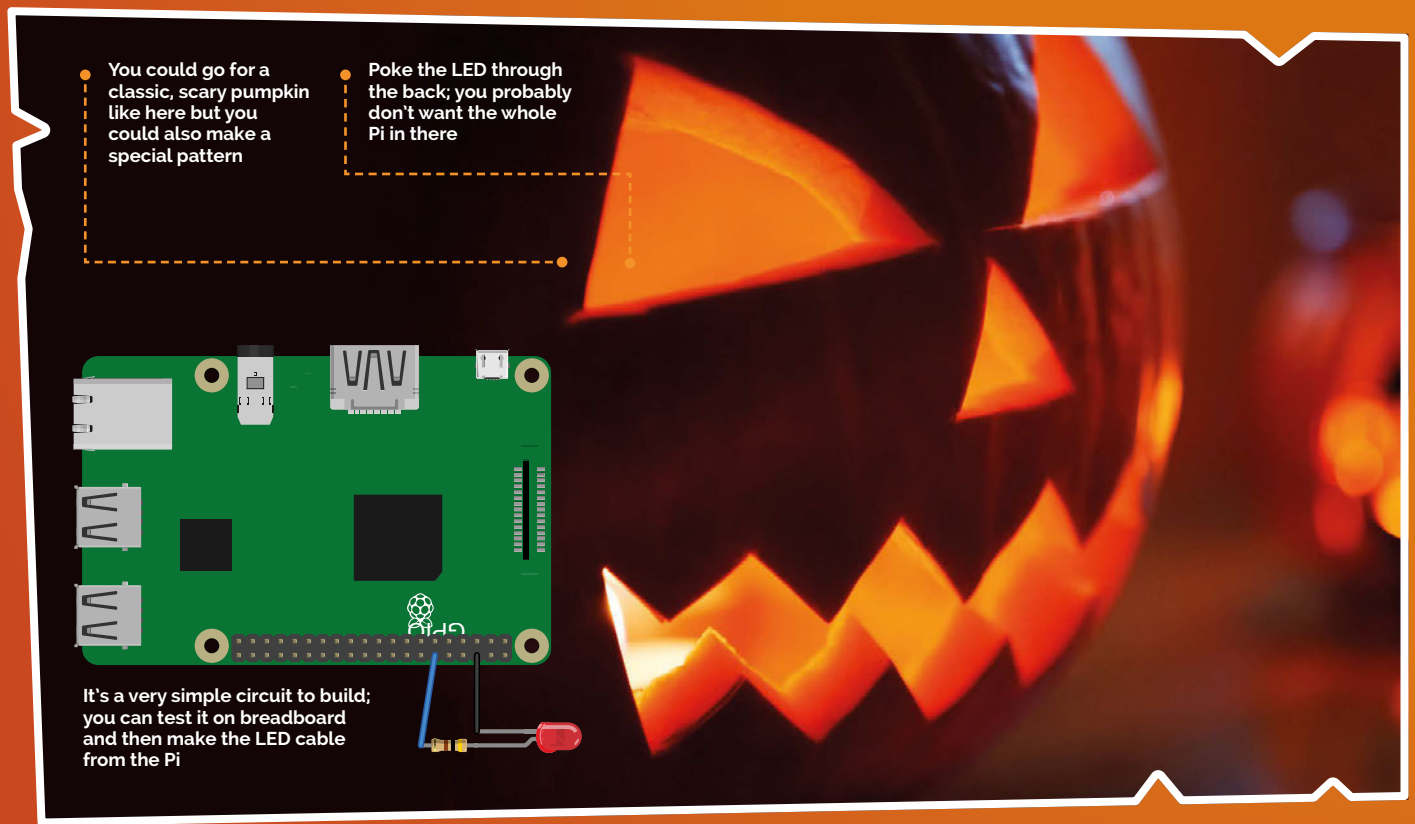
You could add flickering by adding extra complicated components, but instead we're going to do it with some more complicated code instead at no extra cost. Get yourself carving and get ready to make the ultimate electric jack-o'-lantern.

>STEP-01

Carve your pumpkin!

The first and most important step. Kids: ask a grown-up for some help in carving it up. Grown-ups: good luck, you're on your own. If it's your first time carving a pumpkin, it's quite simple; grab a carving pumpkin from your local supermarket, slice off the top with a sharp knife, scoop out the insides with a spoon, and then create your design.

Luckily, as we live in the future with powerful pocket computers called 'smartphones', you can also


You could go for a classic, scary pumpkin like here but you could also make a special pattern
Poke the LED through the back; you probably don't want the whole Pi in there
It's a very simple circuit to build; you can test it on breadboard and then make the LED cable from the Pi

hop on YouTube and search for some pumpkin carving guides. Americans have been doing this for decades, so maybe seek out a video from the US on the subject.

>STEP-02
Extra pumpkin prep

Once you've carved and spooked up your pumpkin appropriately, you'd normally put in a candle to light it up. We need to put the LED in, but it's probably best to leave the Pi outside of the damp, organic innards of the pumpkin. So, carefully drill (or poke with a knitting needle) a hole in the lower-back of the pumpkin. Make it large enough to poke the LED (and perhaps some shrink-wrapped wires) through the hole. Test it with the LED before you hook it all up and make sure there's enough room for it to get through.

>STEP-03
Wire up the circuit

Follow the Fritzing diagram to wire up the circuit on the Raspberry Pi; it's quite simple, though. Pin 6 (GND), which goes to ground, connects to the negative/shorter end of the LED. A resistor then goes between the positive/long end to pin 12. Pin 12 is also GPIO 18, which we'll be using for the code. The best way to construct this is to solder wires to the LED, with the resistor soldered along the positive wire, and then have it all shrink-wrapped. However, with some jumper wires, you can connect it all up with only a little solder on the resistor to the LED.

>STEP-04
Program the Raspberry Pi

Copy or download the Python code onto the Raspberry Pi. If you're writing it out, save it as **candle.py** in the home folder for simplicity. The code uses PWM to change the frequency of the electricity going to the LED. As it changes, the LED flickers as it doesn't receive quite enough power to be solid. We then have this frequency change at random to create an unpredictable flickering effect, much like a candle. Run it in the IDLE shell to give it a go and see for yourself if it's working.

>STEP-05
Run the code

Unless you plan to hook up a monitor and keyboard to your Raspberry Pi just to get it running the code, you'll need to find a way to run it independently. If you're using a Raspberry Pi 3 (or any Pi with a WiFi dongle), you can do this easily by having it connect up to your WiFi, so you can SSH in and run the Python script. The most automated way, though, is to have the script run at boot. To do this, open up the terminal, use `sudo nano /etc/profile` and add this to the bottom: `sudo python candle.py`

candle.py

```
#!/usr/bin/env python

import RPi.GPIO as GPIO
import time
from random import randrange

led_pin = 18

GPIO.setmode(GPIO.BCM)
GPIO.setup(led_pin, GPIO.OUT)

led_pwm = GPIO.PWM(led_pin, 200)

led_pwm.start(100)

def brightness(change_brightness):
        global led_pwm
        led_pwm.ChangeDutyCycle(change_brightness)

def flicker():
       brightness(randrange(0, 100))
       time.sleep(randrange(1, 10) * 0.01)

while True:
        flicker()
```

>STEP-06
Choose a good spot

You'll need to consider a few things when placing your pumpkin; it will have to be in a good spot where everyone can see it, but you also need to make sure you can plug the Raspberry Pi in close by. Hiding the Pi and the cable is quite important as well, but you shouldn't have any issues if you bought a big enough pumpkin.

Sit back, relax, and bask in the glow of your spooky pumpkin.

CODE:
Python
magpi.cc/2dzF94P

Maker Says

"Use your Raspberry Pi to take control of this string puppet

Simon Monk

PUPPET KIT FOR RASPBERRY PI

Your Raspberry Pi pulls all the strings with this innovative puppet kit project

Related

MAPLIN ROBOTIC ARM

Maplin's robotic arm is a much more complex build with more functionality. It can be controlled from a Raspberry Pi with Fuze BASIC.

£50 / $61

magpi.cc/2dLweuN

The Puppet Kit by esteemed maker Simon Monk caught the attention of everybody at *The MagPi*. This quirky project has you detaching the strings from a traditional marionette and hooking them up to servo motors. These are then used with Python code to control the doll.

"How cool," said many team members; "Waah, clowns are creepy," said even more. Maybe it's Halloween coming, or the craze for dressing up as Killer Clowns on the news every night, but we certainly felt this puppet had a touch of *Psychoville* to it.

A fear of psychotic circus performers has never stopped us from building before, and this doll's creepy clown make-up isn't going to stop us now. We quickly had 'Mr Jelly' out of his box and on the operating table.

There's a lot of promise in this build. With everything set up, you can make the puppet walk, wave, and even perform killer dance moves. You can get him to spot your wave and wave back, thanks to the included PIR sensor.

Master of puppets

The central part of the Puppet Kit is its four 9g servos to control the strings of the marionette. The strings are detached from the usual wooden cross and hooked up to little wooden arm extensions.

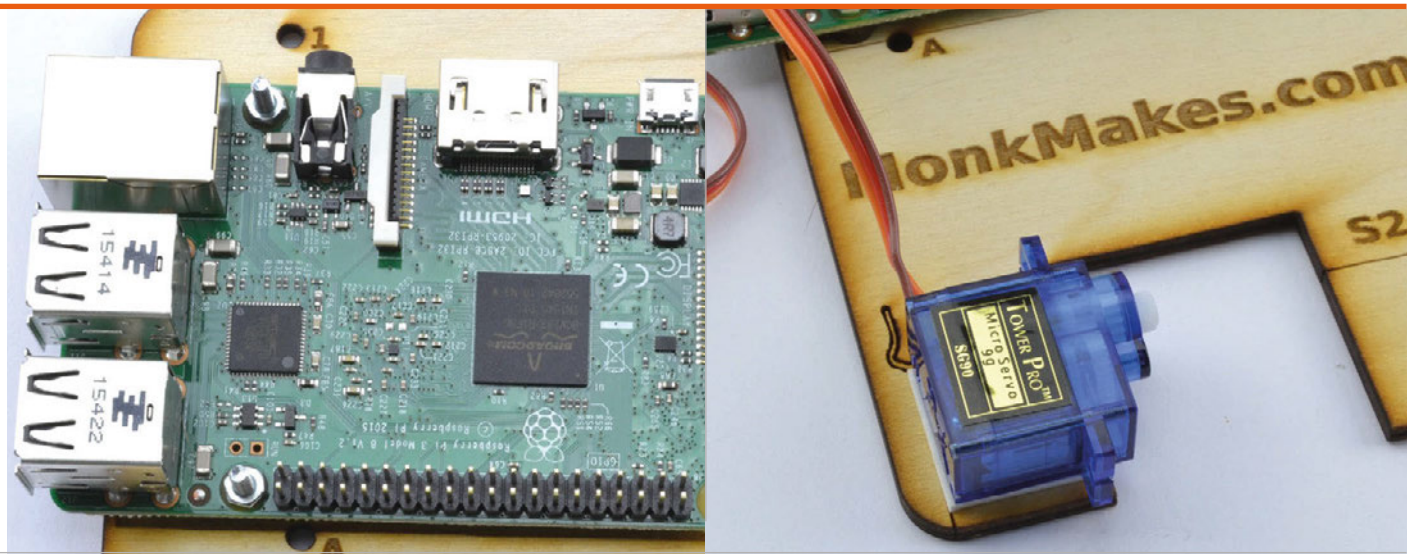
A Servo Six board is wired directly to the GPIO pins on the Raspberry Pi (not included). Aside from the Pi and micro SD card, everything you need is in the box.

Opening the kit reveals a plywood board, with holes marked for various components. To start the build, you screw in your Raspberry Pi and the Servo Six board to this plywood board. We found this first step the fiddliest part of the build, with each screw using a wooden washer and small nut.

Then you move on to the battery box and servo motors. These are all attached using self-adhesive foam blocks, with the servos hanging over the edge of the plywood board. The idea is that you place the board on the edge of a desk or on top of a box, so that the puppet can dangle below.

magpi.cc/2dLjNz3

£30 / $37



Above The plywood board serves as a base for the project, with the Raspberry Pi and other components attached to it

Everything is wired up using the ten female-to-female jumper cables. You connect the servos to the Servo Six board, and the latter directly to the Raspberry Pi. The instructions are clear and include a photograph for each step. It's an ideal project for novice makers.

GitHub. The instructions use Git to download (clone) the files.

Attaching the puppet to the servos requires you to cut the strings. But if you're careful, they can be easily reconnected to the wooden cross to give you back the original puppet. Then we hung the puppet over the edge of a desk and ran the test program. Our marionette sprang to life, just like Chucky from *Child's Play*, and started to walk.

> "You can make the puppet walk, wave, and even perform killer dance moves"

We only had one slight hiccup during the build. We didn't have the micro SD card inserted into the Pi when we started, and couldn't access the card slot when it was time to test the servos (the position of the Servo Six board made it impossible to get in). So we had to remove the Pi, slot in the card, and reinsert it. So make sure you set up Raspbian Jessie with PIXEL before you get started.

Puppet on a string

The software side of things is easy thanks to Simon Monk's Servo Six Python library, available from his

With the build complete, you can head into the two projects. The first is an animation program where you use keyboard commands to control the puppet directly. The second project involves using the PIR sensor to detect motion. As you wave to the puppet, he waves back.

Spending a day with the puppet was highly entertaining. It's an ideal way to introduce young students to Raspberry Pi coding.

Last word

A great project for novices that teaches the basics of servo motor control in a friendly environment. Not for the coulrophobes, though.

★★★★☆

formcard.com

£5 / $6

Maker Says

"A handy, pocket-sized card of strong, meltable bioplastic"

FORMcard

FORMCARD

An eco-friendly plastic which softens in hot water, is FORMcard the future of making?

When Peter Marigold's FORMcard hit crowdfunding site Indiegogo, there was initial confusion: £5/$6 per pack for what appeared to be credit-card-sized lumps of plastic seemed a little over the top. Playing the video, though, revealed the FORMcard secret: it can be softened and worked by simply dunking it in a cup of hot water for a few seconds.

Plastic fantastic

Built from starch-based bioplastic, making it food-safe and biodegradable, each FORMcard represents a potential fix. Suggested projects range from building a compact screwdriver with a bare cross-head bit (FORMcard, surprisingly, having the strength to withstand such use), through to using it to encase electronics for waterproofing or repair broken casings on other devices.

The standard FORMcard kit comes as a pack of three cards, each the same size as a standard credit card though significantly thicker; you can choose from black, white, grey, or a mixture of colours. Its use couldn't be simpler: just as in Peter's video, you pour a cup of hot, clean water, submerge the FORMcard for a minute or so, then fish it out with a spoon and it's ready to use.

This is where things get, quite literally, sticky. Unlike rival Sugru, which is relatively easy to work while soft, FORMcard is extremely keen on retaining your fingerprints for all eternity, and hardens in minutes rather than the average 24-hour curing time of Sugru.

Reusable, remouldable

Here, though, FORMcard's second trick becomes apparent: it's almost infinitely reusable. Unlike Sugru, which hardens permanently, FORMcard can be softened again by applying more heat. Actually removing the softened FORMcard from the surface to which it was applied is more of a challenge, admittedly, but it's still a neat trick and one which allows for temporary repairs.

FORMcards can also be combined, if you need more material for a particular project, and their shape allows you to keep one in your wallet for those just-in-case moments, assuming you can find a source of hot water, of course!

In testing, the FORMcards became soft and workable at around 60°C; if you're looking to house or repair anything which gets even near this temperature, you'll need to look elsewhere for the solution.

Last word

Although not easy to work with and unsuitable for projects that get hot, FORMcard's strength, eco-friendly credentials, and reusability mean it should be a standard in every maker's toolbox.

★★★☆☆

Related

SUGRU

Mouldable by hand, Sugru transforms from a soft putty to flexible rubber overnight – but you can only use it once.

£7 / $12

sugru.com

magpi.cc/2dXcipD

£7 / $9

Maker Says

"Add emotion and fun to your electronic creation"

4tronix

MCROBOFACE

This bright light-up face will add character to your projects

Launched via Kickstarter, McRoboFace is a PCB board with 17 WS2812B RGB LEDs, also known as NeoPixels. These are fully addressable and arranged in the shape of a face. At full power, they're blindingly bright and, while their intensity is adjustable via software, we'd advise purchasing the optional diffuser kit to soften the effect; the frosted acrylic diffuser is easily fitted to the front using three nylon screws, nuts, and spacers.

Either way, you'll need to solder on the supplied four-pin right-angled header to connect it to your Raspberry Pi. It can also be driven by many other microcontrollers, including micro:bit, Arduino, Codebug, BeagleBone, Crumble, and ESP8266. When using it with the Pi, you have two options. The first method is to connect it via a Picon Zero, using output 5 set to WS2812B. Since the Picon Zero also features two H-bridge motor drivers, it's an easy way to create a wheeled robot with an expressive face at the front.

Alternatively, you can hook the McRoboFace up directly to the Pi's GPIO pins 5V and GND, along with GPIO 18 (the PWM pin) for precision control of the NeoPixels. While requiring a few extra setup steps, this method works perfectly well; no voltage level shifting is needed, as the pixels can be controlled using 3.3V quite happily. Incidentally, the fourth McRoboFace pin is a digital out for daisy-chaining with other NeoPixel displays.

The Pi connection method will determine the Python programming method for controlling McRoboFace. Again, a little more setup is required when using the GPIO pins directly, including the importing of the neopixel (rpi-ws281x) library. It's not a major hurdle, however, as you can just adapt the example code from the GitHub repo (**magpi.cc/2dxooY3**).

Controlling the NeoPixels is easy enough, as they're numbered on the PCB: 15 and 16 for the eyes, 14 for the nose, and the rest for the mouth. Since they're all fully addressable, you can adjust the RGB shade and brightness of each precisely. This makes it possible to create some very impressive fade and colour cycle effects. Using Python lists also enables you to easily change several pixels at once for facial expressions.

Last word

McRoboFace is an inexpensive and fun way to add a bit of character to your robots or other creations with facial expressions, or as a general NeoPixel light display. You could even hook it up to an audio input, as Robin Newman did (magpi.cc/2dxqZ4k), to 'sing' along to music!

★★★★☆

Related

NEOPIXEL RING

Available in various sizes, from 12 to 60 NeoPixels, these chainable rings are an alternative to the standard NeoPixel strips.

From £6 / $8

magpi.cc/2dXaWLy

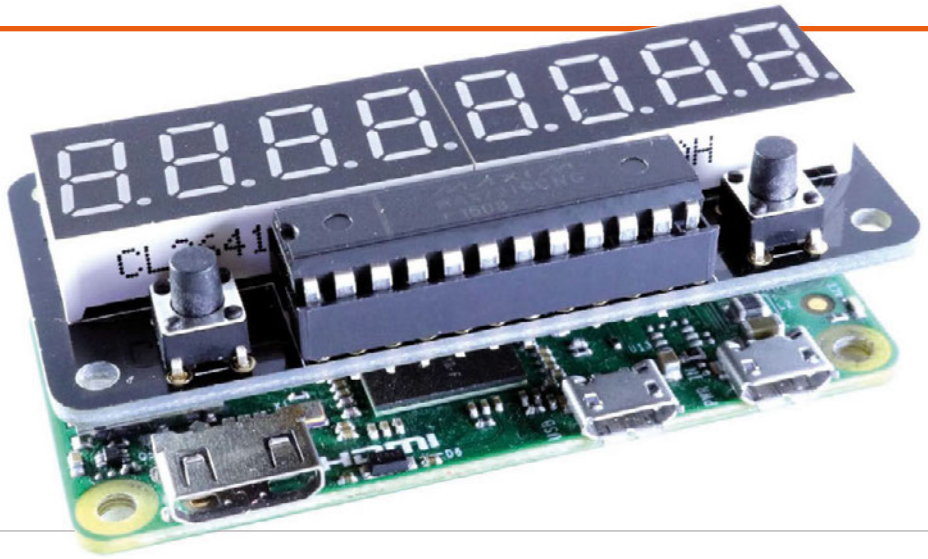
magpi.cc/2d0tGBg

£10 / $12

Maker Says

"An easy-to-use 8-character 7-segment display add-on board"

Average Man



ZEROSEG

Build your own old-school red LED display

While playing around with some generic spare parts, including a standard seven-segment LED unit, Richard Saville – aka Average Man vs Pi (**averagemanvsraspberrypi.com**) – had the idea of creating a more polished, Pi Zero-sized display. Following a lot of reverse-engineering, trial and error, and prototyping, he came up with the ZeroSeg, which features two four-digit display units.

The first thing to note is that it comes in kit form, with numerous components to solder onto the rear and front of the small board, including various resistors and capacitors. Fortunately, there's an excellent online assembly guide to help you, as the parts need to be added in a specific order. Quite a bit of precision is required, too. For instance, the MAX7219CNG chip socket must be flush with the board edge to enable you to cram in the two LED units; when soldering the latter, you also need to take care not to touch previously added components on the rear. Still, it's fun to put together and you get a sense of achievement when it's completed.

To get it working, you need to install the ZeroSeg Python library and spidev, and enable the SPI interface on the Raspberry Pi. In addition to power and ground, it only uses five GPIO pins: 8, 10, 11, 17, and 26; this means there are still plenty to play with if you're breaking them out or stacking the ZeroSeg on top of another board.

The ZeroSeg code library includes a few Python examples to get you started, including a demo that shows off its capabilities, such as the ability to fade the brightness through 15 levels and scroll digits across the display. It's fairly easy to program by adapting examples, although we couldn't figure out a way of showing text; this may well have been added by the time you read this, although some letters (such as M and W) are impossible to reproduce on a seven-segment display. So it's best suited to displaying digits; use cases include a temperature monitor and time/date display. The two programmable mini-buttons are a nice bonus and can be used to switch what's shown.

Last word

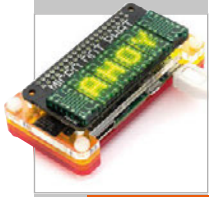
While not as flexible as a matrix display, the ZeroSeg is great for value for money and fun to assemble. More suited to displaying digits than text, it's fine for numerical data, which may be scrolled across the two LED units. The latter are bright enough at full power, although in daylight the white non-lit sectors are very visible.

★★★★☆

Related

MICRO DOT PHAT

Able to display text and numbers, this LED matrix display is very versatile and renders characters in great detail.

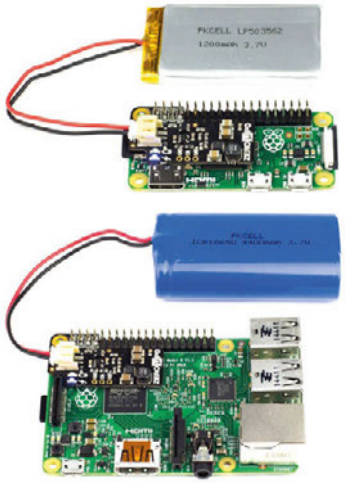


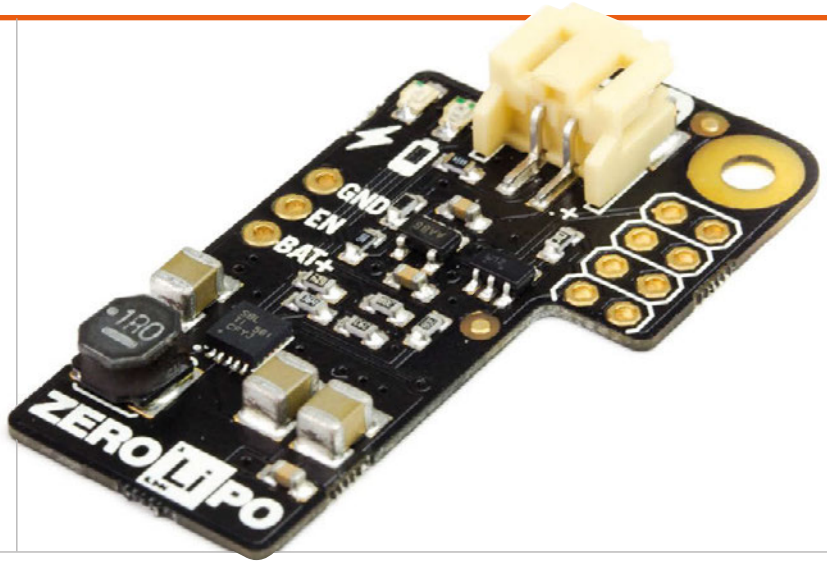
£22 / $27

magpi.cc/2cfq70b

magpi.cc/2coJyZ2

£10 / $13





Maker Says

"Aims to give you the most compact Raspberry Pi power supply possible"

Pimoroni

ZERO LIPO

Reliable and portable power for the Raspberry Pi

The Zero LiPo is a tiny add-on board for the Raspberry Pi that enables you to power it from lithium polymer and lithium ion batteries.

The board itself is tiny. Measuring just 0.8mm thick and weighing 2.9g, it doesn't interfere with your usage of the Raspberry Pi.

It attaches to the eight GPIO pins at the top of the pin layout (covering the two 5V pins, 3.3V, GPIO 3 and 4, and Ground). From here it provides power to the Raspberry Pi, while leaving the micro-USB power socket free.

There are two ways to attach the Zero LiPo to the Raspberry Pi. You can either solder the board to the bottom of the standard GPIO header, or you can solder it to a 2×4 female header.

This second option enables you to attach, and remove, the Zero LiPo to/from the GPIO pins, but it blocks the pins. Both options require deft soldering skills.

In addition to the Pi Zero, you can use the Zero LiPo on any Raspberry Pi model.

Once attached to the Raspberry Pi, the board gets its power from a battery via a JST connector. Just charge up your battery, then plug it in to power up the Raspberry Pi.

Pimoroni is selling a range of LiPo and Li-ion batteries, ranging from £4.50 to £18.

We tested a 1200mAh LiPo and a 2200mAh Li-ion battery. Both battery types function largely the same (plug and go). The board uses a step-up boost converter (TPS61232) to convert the 3-4.2V from the batteries to the 5V used by the Raspberry Pi.

As the battery runs out, you get an alert at 3.4V: a red low voltage warning LED comes on. The board automatically shuts down at 3.0V. This protects the battery.

The Pimoroni blog (**magpi.cc/2d1YwCm**) has detailed tests on how much usage you can expect to get in a variety of common tasks, across the range of batteries.

In addition to the Pi Zero, you will need a JST charger for your battery, such as the Adafruit Micro Lipo (£7.50) or PowerBoost 1000 (£20.50), both also available from Pimoroni.

Related

ANKER ASTRO E1 5200MAH

You can power a Raspberry Pi using most USB battery packs designed for smartphones. These are bulkier and less integrated than the Zero LiPo.

£12 / $16

magpi.cc/2d21w1E

Last word

It's a slick piece of kit, but make sure you factor in the price of the charger and batteries. It's a great option for providing safe power for a portable project, though.

★★★★☆

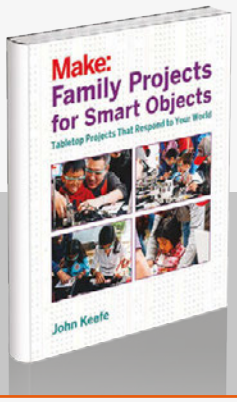
RASPBERRY PI BESTSELLERS

MAKE FAMILY

Maker Media's family-oriented series puts electronics and fun into learning and playing

FAMILY PROJECTS FOR SMART OBJECTS

Author: John Keefe
Publisher: Maker Media
Price: £14.50
ISBN: 978-1680451238
magpi.cc/2evoL2V



Sensors, communication, and the whole Internet of Things encapsulated in simple and fun projects you can do with your children. Code is provided, so even beginners can try the projects out.

MAKE IT GLOW: LED PROJECTS FOR THE WHOLE FAMILY

Authors: Emily Coker, Kelli Townley
Publisher: Maker Media
Price: £14.50
ISBN: 978-1680451054
magpi.cc/2evo9dC

A lovingly presented collection of craft-meets-electronics that will enthral and enthuse your mini-makers. Projects include firefly nightlights, light-up tote bags, fairy wings, thunderclouds, a superhero cape, and more.

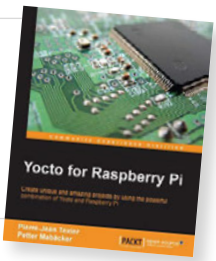
MAKE: TECH DIY: EASY ELECTRONICS PROJECTS FOR PARENTS AND KIDS

Authors: Ji Sun Lee, Jaymes Dec
Publisher: Maker Media
Price: £14.50
ISBN: 978-1680451771
magpi.cc/2evspJS

Felt, paper, and card meet LEDs, resistors, and the good old 555 timer chip, in a collection of projects kids will enjoy making and using – without realising they're learning, too.

YOCTO FOR RASPBERRY PI

Author: Pierre-Jean Texier, Petter Mabäcker
Publisher: Packt
Price: £23.99
ISBN: 978-1785281952
magpi.cc/2evoD38



The Yocto Project is a build system for products on embedded devices – popular boards like BeagleBoard and the Raspberry Pi – and the Pi's extra grunt makes it an ideal platform for developing and trialling Yocto builds of embedded apps, in a more realistic environment than running inside QEMU on your PC.

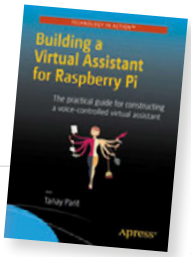
A complex collection of tools, processes, templates, and methods, getting started with Yocto is greatly aided by a well-ordered guide. Texier and Mabäcker provide a step-through guide to working with BitBake, OpenEmbedded-Core, Poky, BSP (the meta-raspberrypi layer), introducing Yocto workflow, building your first system with Poky, and the BSP layer for Raspberry Pi. These layers are assembled as recipes, then put through BitBake to build the image for the Pi's SD card.

After working through BitBake's powerful features, the authors look at Raspberry Pi-specific aspects of developing with Yocto, and introduce a project to work with the Pi's GPIO pins. The provided code is in C, but shouldn't be too much of a stretch for anyone with programming basics. Further Yocto layers follow, built of collections of recipes, for better organisation of larger projects. A home automation project brings together everything learned.

Score ★★★★☆

BUILDING A VIRTUAL ASSISTANT FOR RASPBERRY PI

Author: Tany Pant
Publisher: Apress
Price: £14.99
ISBN: 978-1484221662
magpi.cc/2evszRu



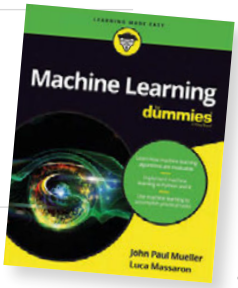
From Siri to Tony Stark's Jarvis, everyone is speaking to virtual assistants, but how about creating your own? Tanay Pant's concise guide does just that and, despite the slightly grating (but presumably postmodern ironic) aspect of the female-voiced assistant greeting those who follow the project with a 1960s assistant-style "Hi, handsome", bear with it as the project is well put together and actually quite useful.

A virtual assistant is made up of speech-to-text (STT), logic, and text-to-speech (TTS). STT is farmed out to Google's powerful service, but other options are considered, and you can substitute in one of them. TTS is provided by the eSpeak package, and some basic code soon gets the reader in 'conversation' with the Pi (once you've acquired a USB microphone for it!). The rest of the book builds the logic layer to add to the assistant's accomplishments.

All code is in Python, and a lot of conversation depends on if-elif-else statements. Siri-style look-ups of definitions from Wikipedia, or the day's weather or business news, form the basics, but adding Selenium testing of your website(s) opens the reader's eyes to other possibilities. A music player, note taker, and Twitter interface are followed by suggestions for further development.

Score ★★★★☆

MACHINE LEARNING FOR DUMMIES



Author: John Paul Mueller, Luca Massaron
Publisher: Wiley
Price: £21.99
ISBN: 978-1119245513
magpi.cc/2evs364

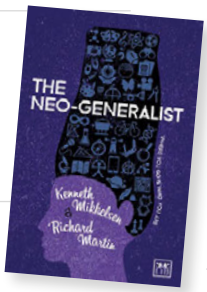
A brave move in a beginner's book is to make the reader learn two languages – R and Python – but R has great strengths in dealing with statistics, and Python is the best general-purpose language for machine learning. It's all about the data, and the language intros get straight to work on manipulating mathematical matrices, lists, and multiple-dimensional arrays.

Unlike many '… for Dummies' series books, this one seems aimed more at traditional learners, with fewer space-filling diagrams, and far more instructive text. To give a rounded picture of machine learning – a vast topic – the book jumps between practical and informational sections, and some readers may find themselves skipping back and forth among sections to get the most out of it.

And what a lot there is to get out of this one: the future of machine learning; language intros; maths and statistics (all of that high school learning you've forgotten); a great introduction to many of the algorithms you need to know; working examples in R and Python to illustrate what you've learned; and a great selection of machine learning problems tackled using the skills you've been learning, followed by a look at where to explore next. Comprehensive, and not just for dummies.

Score ★★★★☆

THE NEO-GENERALIST



Author: Kenneth Mikkelsen, Richard Martin
Publisher: LID
Price: £12.99
ISBN: 978-1910649558
magpi.cc/2evq7KV

While the US Department of Labor states that two-thirds of children in primary schools today will work in jobs that have not yet been invented, many of us have been making up careers as we go along for a long time. The rhyme 'Jack of all trades / Master of none' was completed in the original Elizabethan form with 'Oft' times better / than a master of one.'

The Neo-Generalist takes in all who switch from generalist to hyper-specialist: the multi-hyphenate, portfolio or slash career; full stack engineers; tinkerers; inventive dilettantes who are a familiar feature at makerspaces and at Python conferences where, for example, a surprising percentage of coders have a background as professional musicians; and those who follow a 'continuum of options'.

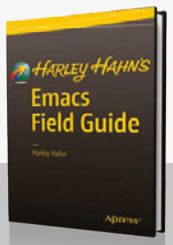
The authors' sweeping style – reminiscent of Leslie Kenton – won't be to all tastes, but they've done a magnificent job of showing multiple possibilities that exist for creative people in our changing times, illustrated with dozens of interviewees from many walks of life, and frequent crossings between disruptive technology, the arts, and social enterprise. If you find yourself 'living in more than one world', take heart: you're certainly not alone.

Score ★★★★☆

ESSENTIAL READING: GNU EMACS

Get to grips with the programmer's editor that thinks it's an operating system

Harley Hahn's Emacs Field Guide



Author: Harley Hahn
Publisher: Apress
Price: £19.99
ISBN: 978-1484217023
magpi.cc/2evrRUz

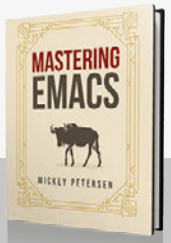
The veteran tech author brings his beginner-friendly style to introducing Emacs. Abounds with history, geekiness, and clear explanations.

Emacs

Author: N/A
Publisher: GNU
Price: N/A
ISBN: N/A
magpi.cc/2evq6qd

Emacs is a self-documenting editor with built-in tutorial. So, **Ctrl-h a** searches for the appropriate Emacs info page.

Mastering Emacs: 2nd Edition



Author: Mickey Petersen
Publisher: ebook – masteringemacs.org
Price: $39.99
ISBN: N/A
magpi.cc/2evrhGi

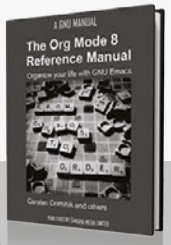
Philosophical and practical guide to the ultimate 'tinkerer's editor', updated for Emacs 25. Thoughtful, immersive, and full of useful workflow tips.

Sacha Chua's Emacs blog

Author: Sacha Chua
Jim Mlodgenski & Kirk Roybal
Publisher: N/A – blog
Price: N/A
ISBN: N/A
magpi.cc/2evsOvW

Rivalling (or surpassing!) the EmacsWiki, from an A3 poster introducing Emacs to beginners, to detailed modifications of numerous modes.

The Org Mode 8 Reference Manual



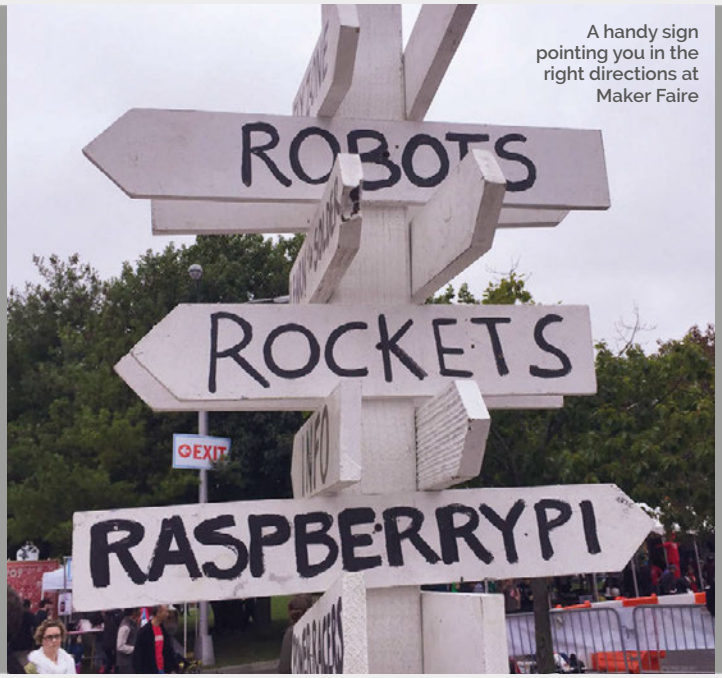
Author: Carsten Dominik
Publisher: Samurai Media
Price: £16.03
ISBN: 978-9881327703
orgmode.org

Written by Org Mode's original author. Organise your projects, your business, and your life, with Emacs' secret weapon.

THE MONTH IN RASPBERRY PI

Everything else that happened this month in the world of Raspberry Pi

WORLD MAKER FAIRE NEW YORK



A handy sign pointing you in the right directions at Maker Faire

One of the biggest events on the maker calendar is the World Maker Faire in New York, and it's a bit of a tradition with the Raspberry Pi team; before the computer came out in 2012, the Raspberry Pi was being demonstrated by (the very small) team Pi.

Things have changed a lot since then and Raspberry Pi was a prominent presence at this year's event, with members from the Foundation and Trading company attending to help out. This included *The MagPi*'s Lorna Lynch, who has blogged about the experience in detail on the Raspberry Pi blog (**magpi.cc/2emXdBX**).

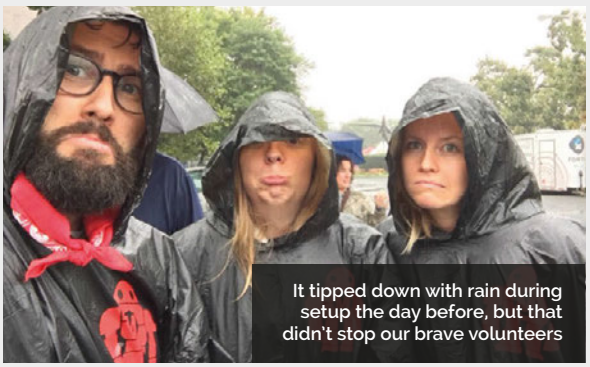
"As in previous years, there were many excellent Raspberry Pi-based projects, as well as familiar faces from the Pi community. There was an excellent display of Pi-controlled Lego Mindstorms robots. We also met the guys from Pi Supply showcasing their new JustBoom equipment, bringing affordable high-quality audio to Raspberry Pi users. Eager experimenters of all ages came to try out our Sense HAT activities, and to tell us about the Pi projects they had made at home. One man was even wearing a Pi Zero as a necklace!"

It looks like it was a lot of fun; we hope to see you there next year, or maybe even at the Bay Area Maker Faire in May!

RASPBERRY PI LIVE!

magpi.cc/2ejpaoK

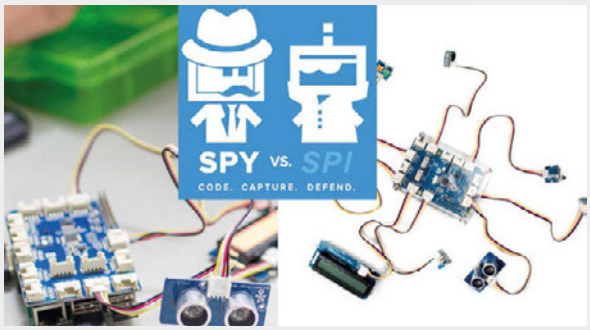
Feel like you missed out by not going to see Raspberry Pi in New York? The team recorded a live video tour of the Pi booth and surrounding areas at the Maker Faire, which you can watch on the Raspberry Pi Facebook page by following the shortlink. It might be a good idea to get the page liked if you want to be ready for the next livestream: facebook.com/raspberrypi



It tipped down with rain during setup the day before, but that didn't stop our brave volunteers

CROWDFUND THIS!

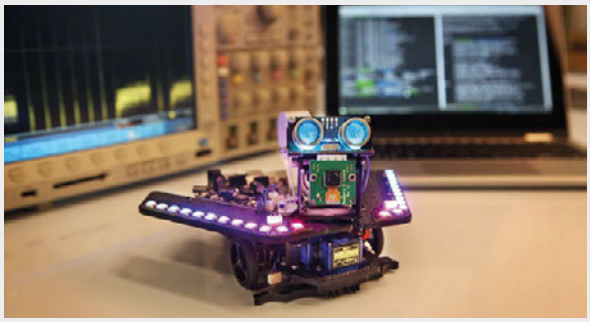
The best crowdfunding hits this month for you to check out...



SPY V. SPI

kck.st/2dfNwmG

A lot of Raspberry Pi robot kits you can buy have an educational slant, teaching you code and/or robotics as you create and program your robot. Spy v. sPi takes this educational angle in a different direction, with the robots being built and programmed to fulfil missions in what Dexter Industries are calling a 'capture-the-flag adventure'. This is done by using sensors to protect or capture an electronic treasure the teams are vying for. It sounds like a lot of fun, and with your help they can get it out.



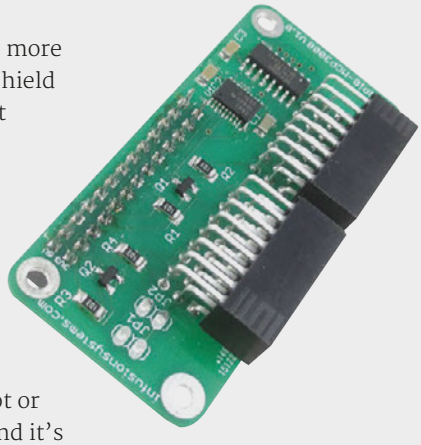
SPIRIT ROVER

kck.st/2dlan05

This campaign will have finished by the time this goes to press. However, it's hit the goal so expect to see more of it soon: it's another learning robot, but this one is based on Mars rovers! It combines Raspberry Pi and Arduino for the usual robo-education of building and coding. This one is fairly unique, as it has a row of awesome NeoPixels on its chassis and just under the ultrasonic sensors to make it look like it has a face. It's got a lot of amazing functions, so it's definitely one to keep an eye on.

PISHIELD

kck.st/2dCw8c1



Here's something that's a bit more of a utility. The PiShield is a shield for the Pi Zero that adds eight 5V analogue sensor ports and four I²C device ports to the Pi. As its form factor is designed for the Pi Zero, that means it also fits on other Raspberry Pis, as long as they have the 40-pin GPIO. This makes it pretty useful for many robot or home automation projects, and it's actually already been funded. Just a $20 (Canadian) pledge guarantees one for yourself.

BEST OF THE REST

Here are some other great things we saw this month

magpi.cc/2ejoyiX

DRONE WITH A PI CAMERA

This popped up in our Twitter feed from Manoj Nathwani; he's managed to attach and power a Pi Zero and camera on top of a Parrot MiniDrone, and still get it to fly. There's some pretty tight weight limits, it seems, and it wasn't easy. Follow the link: it's a great read.

magpi.cc/2ejmNCr

PI CART

We've seen many Raspberry Pis stuffed into gaming peripherals, but we really like this project: a Pi Zero has been stuck into the cartridge for Back to the Future on the NES (bad) and modified into a full retro console (good). Power, HDMI, and USB ports have been brought out to make them easier to access, as well.

COMMUNITY PROFILE

MATT REED

Matt spends his days creating awesome builds for integrated marketing agency redpepper in Nashville, Tennessee

Matt Reed

Category: Professional maker
Day job: Creative technologist
Website: mcreed.com
magpi.cc/2engP7x

Matt's background is in web design/development, extending to graphic design in which he acquired his BFA at the University of Tennessee-Knoxville. In his youth, his passion focused on car stereo systems, designing elaborate builds that his wallet couldn't afford. However, this enriched his maker skill set by introducing woodwork, electronics, and fabrication exploration into his creations.

Having joined the integrated marketing agency redpepper eight years ago, Matt originally worked in the design and production of microsites. However, as his interests continued to grow, demand began to evolve, and products such as the Arduino and Raspberry Pi came into mix. Matt soon found himself moving away from the screen toward physical builds.

"I'm interested in anything that uses tech in a clever way. Whether it be AR, VR, front-end, back-end, app dev, servers, hardware, UI, UX, motion graphics, art, science,

Below Matt hosts the redpepper 'Touch of Tech' online series, highlighting the latest in interesting and unusual tech releases

Sniffur allows Matt to keep tabs on his roaming greyhound, Bean, using a collar-mounted beacon and three Raspberry Pis

or human behaviour. I really enjoy coming up with ideas people can relate to."

Matt's passion is to make tech seem cool, creative, empowering, and approachable, and his projects reflect this. Away from the Raspberry Pi, Matt has built some amazing creations such as the Home Alone Holidaython, an app that lets you recreate the famous curtain shadow party in Kevin McCallister's living room. Pick the shadow you want to appear, and projectors illuminate the design against a sheet across the redpepper office window. Christmas on Tweet Street LIVE! captures hilariously negative Christmas-themed tweets from Twitter, displaying them across a traditional festive painting, while DOOR8ELL allows office visitors the opportunity to Slack-message their required staff member via an arcade interface, complete with 8-bit graphics. There's also been a capacitive piano built with jelly keys, a phone app to simulate the destruction of cars as you sit within traffic, and a working QR code made entirely from Oreos.

Playing the 'technology advocate' role at redpepper, Matt continues to bridge the gap between the company's day-to-day business and the fun, intuitive uses of tech. Not only do they offer technological marketing solutions via their rpLAB, they have continued to grow, incorporating Google's Sprint methodology into idea building and brainstorming within days of receiving a request, "so having tools that are powerful, flexible, and cost-effective like the Pi is invaluable."

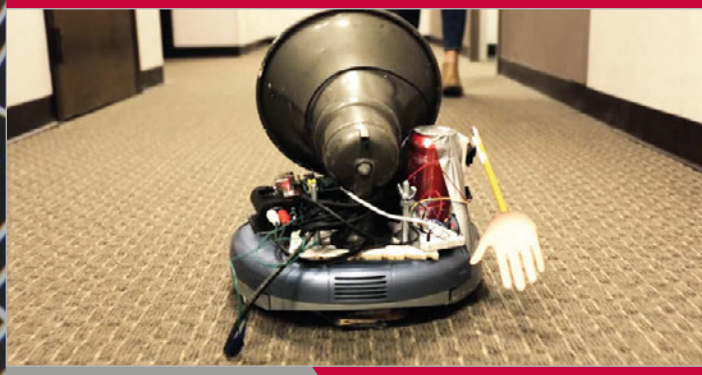
> "I'm interested in anything that uses tech in a clever way"

"I just love the intersection of art and science," Matt explains when discussing his passion for tech. "Having worked with Linux servers for most of my career, the Pi was the natural extension for my interest in hardware. Running Node.js on the Pi has become my go-to toolset."

We've seen Matt's Raspberry Pi-based portfolio grow over the last couple of years. A few of his builds have been featured in *The MagPi*, and his Raspberry Preserve was placed 13th in the Top 50 Raspberry Pi Builds in issue 50.

There's no denying that Matt will continue to be 'one to watch' in the world of quirky, original tech builds.

HIGHLIGHTS



SLACKBOT BOT

vimeo.com/117277575

Users of the multi-channel messenger service Slack will appreciate this one. Beacons throughout the office allow users to locate Slackbot Bot, which features a tornado siren mounted on a Roomba, and send it to predetermined locations to deliver messages. "It was absolutely hilarious to test in the office."

DOORJAM

vimeo.com/183868335

Walk into a room with Doorjam enabled, and suddenly your favourite tune is playing via boombox speakers. Simply select your favourite song from Spotify, walk within range of a Bluetooth iBeacon, and you're ready to make your entrance in style.

BOOMILLUMINATOR

vimeo.com/65828183

The Boomilluminator, an interactive art installation for the Red Bull Creation Qualifier, used LEDs within empty Red Bull cans that reacted to the bass of any music played. A light show across the cans was then relayed to peoples' phones, extending the experience.

RASPBERRY JAM EVENT CALENDAR

Find out what community-organised, Raspberry Pi-themed events are happening near you...

4 BALTIMORE RASPBERRY JAM
Baltimore, MD, USA
3 RASPBERRY JAM BOGOTÁ
Bogotá, DC, Colombia
1 TOKYO RASPBERRY JAM #007
Hodokubo 2-1-1, Hino, Tokyo, Japan

PUT YOUR EVENT ON THE MAP

Want to add your get-together? List it here:

raspberrypi.org/jam/add

FIND OUT ABOUT JAMS

Want a Raspberry Jam in your area? Want to start one? Email Ben Nuttall about it:

ben@raspberrypi.org

HIGHLIGHTED EVENTS

1 TOKYO RASPBERRY JAM #007

When: Sunday 6 November
Where: Hodokubo 2-1-1, Hino, Tokyo, Japan
magpi.cc/2dNUfT6
The Japanese Raspberry Pi Users Group is putting on a Jam for Tokyo locals to learn about the Pi.

2 2ND WIMBLEDON RASPBERRY JAM

When: Sunday 13 November
Where: Wimbledon Library, Wimbledon, UK
magpi.cc/2dNW4zu
Projects and talks from teachers and children to help inspire people in computing and using the Pi.

3 RASPBERRY JAM BOGOTÁ

When: Saturday 19 November
Where: Avenida El Dorado Carrera 45 # 26 - 33, Bogotá, DC, Colombia
miraspberrypi.com
Presentations and workshops at the first and longest-running Latin Raspberry Jam.

4 BALTIMORE RASPBERRY JAM

When: Saturday 3 December
Where: Digital Harbor Foundation Tech Center, Baltimore, MD, USA
magpi.cc/2dNYFsU
Dedicate some time to exploring the Raspberry Pi or working on your own Pi projects.

REGULAR EVENTS

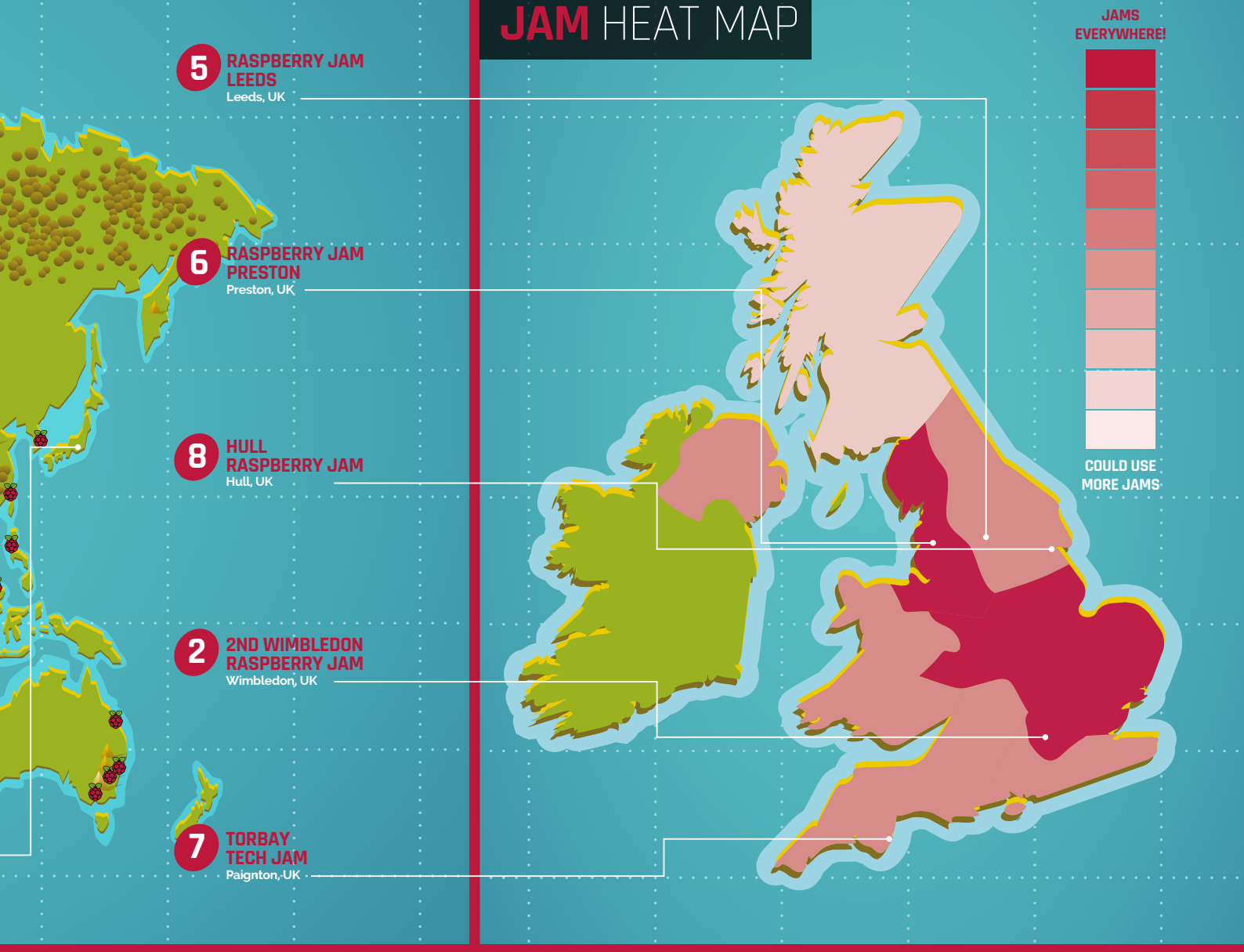
5 RASPBERRY JAM LEEDS

When: Wednesday 2 November
Where: Swallow Hill Community College, Leeds, UK
magpi.cc/2dNPDfP
Everyone is invited for a couple of hours of computing fun, talks, demonstrations, and hands-on workshops.

6 RASPBERRY JAM PRESTON

When: Monday 7 November
Where: Media Innovation Studio, Preston, UK
magpi.cc/2dNRpok
Learn, create, and share the potential of the Raspberry Pi at a family-friendly event.

JAM HEAT MAP



7 TORBAY TECH JAM

When: Saturday 12 November
Where: Paignton Library and Information Centre, Paignton, UK
torbaytechjam.org.uk
A fun, informal, and family-friendly event that aims to inspire people to get into code and take up STEM subjects.

8 HULL RASPBERRY JAM

When: Saturday 12 November
Where: Malet Lambert School, Hull, UK
magpi.cc/2dNRAJ6
Bringing people together from across a wide area to discover the exciting potential of the Raspberry Pi.

FILL IN THE GAPS!

SCOTLAND NEEDS RASPBERRY JAMS

Raspberry Jam community manager Ben Nuttall would like you to help Raspberry Pi spread Raspberry Jams around the country, and one area that could do with more is Scotland. If you're handy with a Raspberry Pi and know others who are, see over the page to find to some top tips on setting up and getting people interest in attending a Raspberry Jam near you.

The Glasgow Raspberry Pi Day was great: let's get more Jams in Scotland!

BLACKPOOL RASPBERRY JAM: AN INTERVIEW WITH **LES POUNDER**

Practical tips for running a Jam for your local community from the chief, **Les Pounder**

Contributor to the magazine and Raspberry Jam runner Les Pounder talks to us about his experiences.

How did you find out about Raspberry Pi?
"Having used Linux since the late 1990s, I was always on the lookout for new Linux devices. Whilst reading the BBC's technology page, I stumbled upon Rory Cellan-Jones's piece introducing a new small computer, which at the time resembled a USB flash drive. I was intrigued and so, along with many others, I was online at 6am, 29 February 2012 and managed to secure my first Raspberry Pi."

LES POUNDER

Les Pounder is a maker, author, and hacker who lives in the UK. He regularly works with the Raspberry Pi Foundation to deliver Picademy training to teachers. He also writes a blog at **bigl.es** for some of his crazy ideas.

How did you get involved in the Raspberry Pi community?
"Since day one I have been a staunch supporter of the Raspberry Pi as a platform for social change and invention. When I first started in the community, I knew nothing about programming and electronics, but with the help of the community and quite a lot of rather basic questions, I quickly understood what could be done with the Raspberry Pi. The main service that the community provides is support. Without it, the Raspberry Pi would just be another single-board computer vying for the attention of the masses. The community embraced the Raspberry Pi and created many wonderful projects that benefit everyone in many different ways. Children learn to code, become inspired through science and engineering thanks to Astro Pi, and learn how data can be used to shape our lives. The community are the backbone that support the project, and I would like to say thanks to every member of the Raspberry Pi community."

What was the first Raspberry Jam you attended?
"My first Jam was in Manchester, hosted by a fresh-faced Ben Nuttall. At this Jam I met many like-minded individuals, including a rather young Amy Mather who has now gone on to great things. This Jam was one of the very first to exist and, at the time, it was testing the water as to how a Jam should be organised. There were lots of tables full of Raspberry Pis being used to play videos using XBMC, and children learning to make games with Scratch and doing basic Python programming."

Why did you decide to start the Blackpool Raspberry Jam?
"Blackpool isn't exactly a tech hub. Our transient population relies on seasonal work and, as such, Blackpool suffers from many social issues, of which poverty is one. I started Blackpool Raspberry Jam as a way to introduce computing and creating inventions to the children of the area. We take the Jam on the road to the many libraries of Blackpool and its surrounding boroughs. Blackpool Libraries have supported our Jam since day one and provide a free venue inside a local library, which means that we don't have to charge our attendees, and this enables us to provide free access to the Raspberry Pi."

How did you go about organising the first Blackpool Jam?
"Once I organised a venue with Blackpool Libraries, the rest just fell into place. I already had plenty of Raspberry Pi computers, power supplies, and cables. All I needed were keyboards, mice, and

screens, which the local library was able to make available to us. But really, for a Jam all you need is a space, some tables, and access to power and WiFi. Then invite people from your local community via posters in community spaces. We approached Blackpool Council to provide advertising across Blackpool at all public libraries and museums. Once we had the advertisements and venue sorted, everything else was easily manageable thanks to the great team of STEM Ambassadors that work with me at Blackpool Raspberry Jam."

What activities did you put on at the Jam?

"I offered lessons for those new to the Raspberry Pi to enjoy. Nothing formal, just fun bite-size projects that can be completed with very little code and in very little time: ideal for children with a short attention span. Seriously, you can have so much fun using a jelly baby as a push-button burp trigger! For more advanced attendees, we provided space and facilities for them to show their projects to the group. We've seen robots, scary spooks that react to sound, and many LED projects created by children in the local area."

How did the Jam go? How many people attended?

"For our first Jam we had around 20 people turn up, including Raspberry Pi co-founder Pete Lomas who gave a great talk on how the Pi came to life. Each month at the Jam we now see around 12 people attend, which is perfect for the small space that we have. What I like about just having 12 people is that we have parents learning with their children, and my team and I have the time to talk to them and offer advice, ideas, and suggestions on all manner of Raspberry Pi queries."

SETTING UP YOUR OWN JAM: LES'S TOP TIPS

01. EXPERIENCE

Attend a few different Jams in your area and get a feel for how each of them is run. Take the best bits and use them for your Jam.

02. COLLEAGUES

Finding support and help from like-minded persons is key to longevity. A good resource is your local STEM Ambassadors, who provide outreach for schools on many different topics.

03. PERSEVERANCE

Don't worry if you don't attract many people – quality of interaction with your attendees will create a better Jam than having hundreds of people that you never speak to.

04. BUDGETING

Equipment can be expensive, but local councils and schools regularly get rid of old kit and this can be recycled for use with the Raspberry Pi.

LAUNCH LIKE A PRO WITH NOOBS

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YOUR LETTERS

Across generations

I am really pleased that the Pi is doing so well. Its popularity and success mean that even after many years I have been able to return to playing with computers.

I started in the very late Seventies with Apple, BBC, and Sinclair(s) at work, as well as a Video Genie (Tandy TRS80) at home. I also joined a local computer group. Word processors such as Scripsit, and spreadsheets like Visicalc, were great, but it was the ability to write my own software that took up so much of my time and was so rewarding.

Time moved on, software got better, I got busy, and I had to be productive in my paid-for work. With that and the fact that the PC had arrived, a lot of the fun went out of computers and I had very little time to play.

Now I have retired, and several Raspberry Pis later, I'm loving it. Solar warming air panels, temperature sensors, fans, and a whole load of tin cans painted black. It worked. Mail box and gate monitoring, with an announcement and an additional email when I get post or leave the gate open. Yes, I'm getting old now. Every morning I get a spoken message to take my pills, weekly reminders to record blood pressure, and if the internet connection goes down, WiMax here, I get another alert.

Now I have an Asterisk SIP PABX for the house phones, a Kodi media server, and I'm about to design, test, and install a water supply monitor, with alerts for excessive water use by my pool in case I get a leak. This can potentially save a future €2,000 water bill.

If the Pi hadn't been a thing, I may never have had the chance to do this much. It's not just the new generation that gain; it's the likes of myself, the first computing generation that had the same sort of start with those early, DIY boxes.

Here's to someone who has achieved even more, sending in a letter in another 40 years' time, and reminiscing how it all started with the first bite of the Pi.

Peter Drew

You're not the only retired person we've spoken to who has found new life in coding thanks to the Raspberry Pi; in fact, we've come across people of all ages who are taking up coding after a long break or trying it for the first time, thanks to the Raspberry Pi. We like to think it's the unique mix of an excellent community of people sharing amazing things, and a very low barrier to entry price-wise that's helped with this. We're glad to hear you've benefited from it as well!

There's a lot that comes with the kit other than the keyboard

International keys

I've just received issue 50, along with an email from my wife asking if I wanted to renew the subscription. I actually told a client I had to call them back so I could phone my wife and tell her not to cancel it under any circumstances!

It was great to learn that the Raspberry Pi Foundation are offering an official starter kit as, having bought Pis from the start (actually being one of the first people to email them about it before the website was even set up), there has often been difficulty getting peripherals that work first time. It's not the case any more, but it was when they first came out.

What disappoints me is the keyboard seems to be the standard US layout, and not the UK layout we know and love. I know there are only two differences between the two: the placement of the " and @ symbols. For a developer like me, though, that's a massive difference between code working

Make it happen

Dear MagPi,
Congratulations on 50 issues and 10 million Pis. I'm happy to see that in your list of the 50 greatest Raspberry Pi projects of all time, no fewer than two were made at Makespace, a maker community and space in Cambridge. Both Tom Oinn's mind-bending robot Triangula and Brian Corteil's Digital Zoetrope might never have been made without Makespace's laser cutters, electronics equipment, and assorted other kit, and above all, its supportive and enthusiastic community.

Around the world, makerspaces are springing up and helping to equip and train a whole generation of makers, from beginner to expert and from children to pensioners. If they are anything like Makespace, I expect they're all hotbeds of Raspberry Pi projects, too. Perhaps we might see a feature on them in a future issue?
Mark Wainwright

Hi Mark; we've heard many wonderful things about the Makespace in Cambridge, especially as its in the Pi's home town. We don't have anything to announce just yet, but we definitely have been talking about doing some stuff on makerspaces: watch this space!

and having to spend hours going through it to find your mistake.

Can you let us know via the next issue if that's the actual keyboard we will receive, or if UK buyers will get the UK version? I buy these for people all the time as they're so inexpensive, so knowing I can get a starter kit in a UK layout will tell me whether to purchase one for those people or not.
Ian Williams

Hi Ian; we hope you didn't get in any trouble with your client for having to hang up! As for the layout of the official keyboard, it's the American layout even on those bought in the UK for the moment. It's still a lovely little keyboard, and well worth having to change your thinking around a bit just to make sure you're using the right keys. You could also probably pick up another keyboard that will work for very little money if you absolutely need it!

FROM THE FORUM: ARTICLE DATABASE

The Raspberry Pi Forum is a hotbed of conversations and problem-solving for the community - join in via **raspberrypi.org/forums**

Hello,
It would be very useful to have a table of contents for all issues (regular issues and all special topic issues) of *The MagPi* which could be searched.

For example, it would be useful when I would like to find all issues of *The MagPi* which are part of a guide to learn C (which would be issues 47, 48, and 49).

Is something like this already available? If not, would it be possible to produce something like this?
Best regards,
Supermerlin

There's a database available for the first 30 issues of *The MagPi* (**magpi.cc/2ds5RbZ**) and we have heard of a few people that keep their own database of all the articles in each issue. It's absolutely feasible, though, and we'd certainly welcome someone creating and maintaining a database for us online, as it would help out the editorial team at times.

If you have a public database of all *The MagPi* articles, please get in touch; we can try to do something to help and make sure it's got a bit more notoriety!

WRITE TO US

Have you got something you'd like to say?
Get in touch via **magpi@raspberrypi.org** or on The MagPi section of the forum at: **raspberrypi.org/forums**

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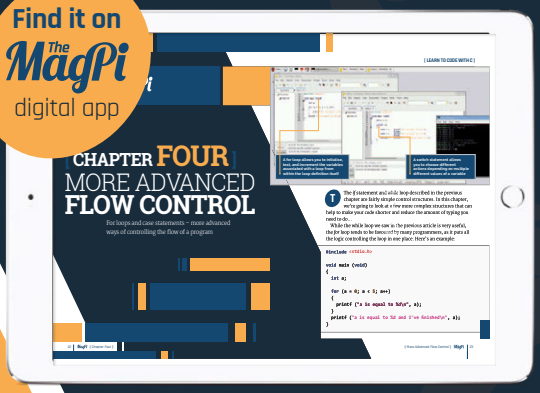

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MATT RICHARDSON

Matt is Raspberry Pi's US-based product evangelist. Before that, he was co-author of *Getting Started with Raspberry Pi* and a contributing editor at *Make:* magazine.

MAKING LIFE CHANGES

Matt Richardson tells his story of going from hobbyist to career maker

Making things can change your life. It did for me, and I hear the same from others all the time.

After I graduated from university in 2003, I jumped immediately into the workforce. I landed in New York City's entertainment industry, which is where I'd dreamed of working since I was young. I was excited to be a staffer on a major television show, where I learned what it takes to produce a weekly television drama. I slowly worked my way up the ladder in the television industry over a few years.

There's a lot to admire about how film and television content is produced. A crew of over one hundred people with creative and technical talents come together to create a piece of entertainment, under the watchful eye of the director. It's an enormous piece of creative collaboration, but it's also a business. Everyone does their part to make it happen. It's incredible to see a television show get made.

I had found a niche in the television industry that I did well in, but eventually I hit a rut. I had a small role in a big piece of work. I wanted to be more creative, and have more autonomy and influence over what I was helping to create. It was at that time that I started closely following what makers were doing.

Feeling inspired by the work of others, I started to make things with microcontrollers and electronics. I'd then share how to do these projects online. Eventually, I was contributing projects to *Make:* magazine and I was soon able to make side money from making things for companies, writing about how to make, and writing about what others were making. Soon enough, I was finding enough jobs to leave the television industry and work as a maker full-time.

That eventually led to my current job, doing outreach for Raspberry Pi in the United States. It's incredibly gratifying work and despite the long road to get there, I couldn't be happier with what I'm doing. The spare time I invested in making things as a hobby has paid off greatly in a new career that gives me creative freedom and a much more interesting work day.

Make it happen

I meet people all the time who have stories about how making has had an impact on their lives. At World Maker Faire New York recently, I met student Gerald Burkett; he told me his story of becoming a maker. He said, "I'm doing things I wouldn't have ever dreamed of just four years ago, and it's changed my life for the better." And Gerald is having an impact on others as well. Even though he's soon graduating, he's encouraging the school's administration to foster makers among students. He says that they "deserve an inviting environment where creativity is encouraged, and access to tools and supplies they couldn't obtain otherwise in order to prototype and invent."

Because of more accessible technology like Raspberry Pi and freely available online resources, it's easier than ever to make the things that you want to see in the world. Whether you're a student or are far down a particular career path, it's also easier than ever to explore making as a passion and potentially also a livelihood.

If you're reading this and you feel like you're stuck in a rut with your job, I understand that feeling and encourage you to pursue making with vigour. There's a good chance that what you make can change your life. It worked for me.

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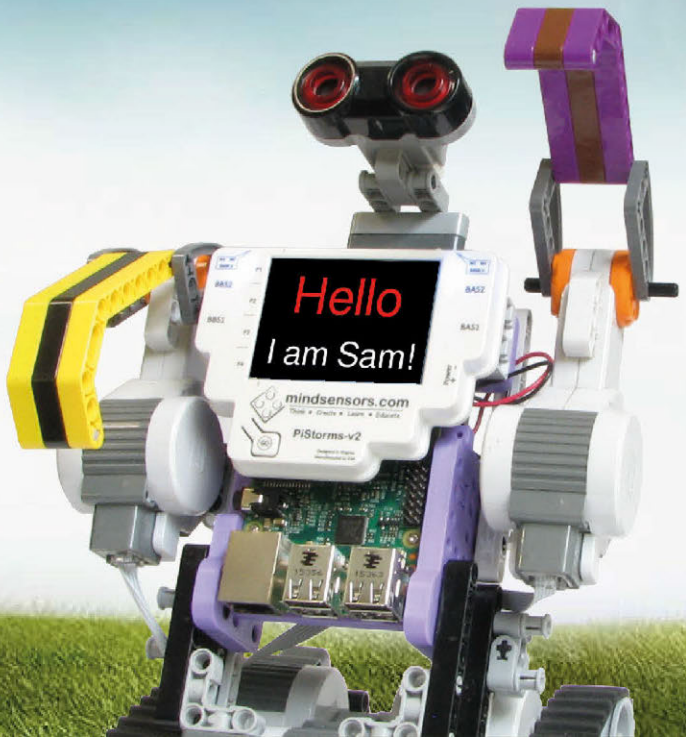

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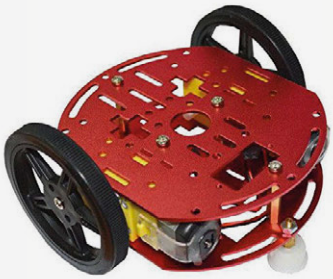

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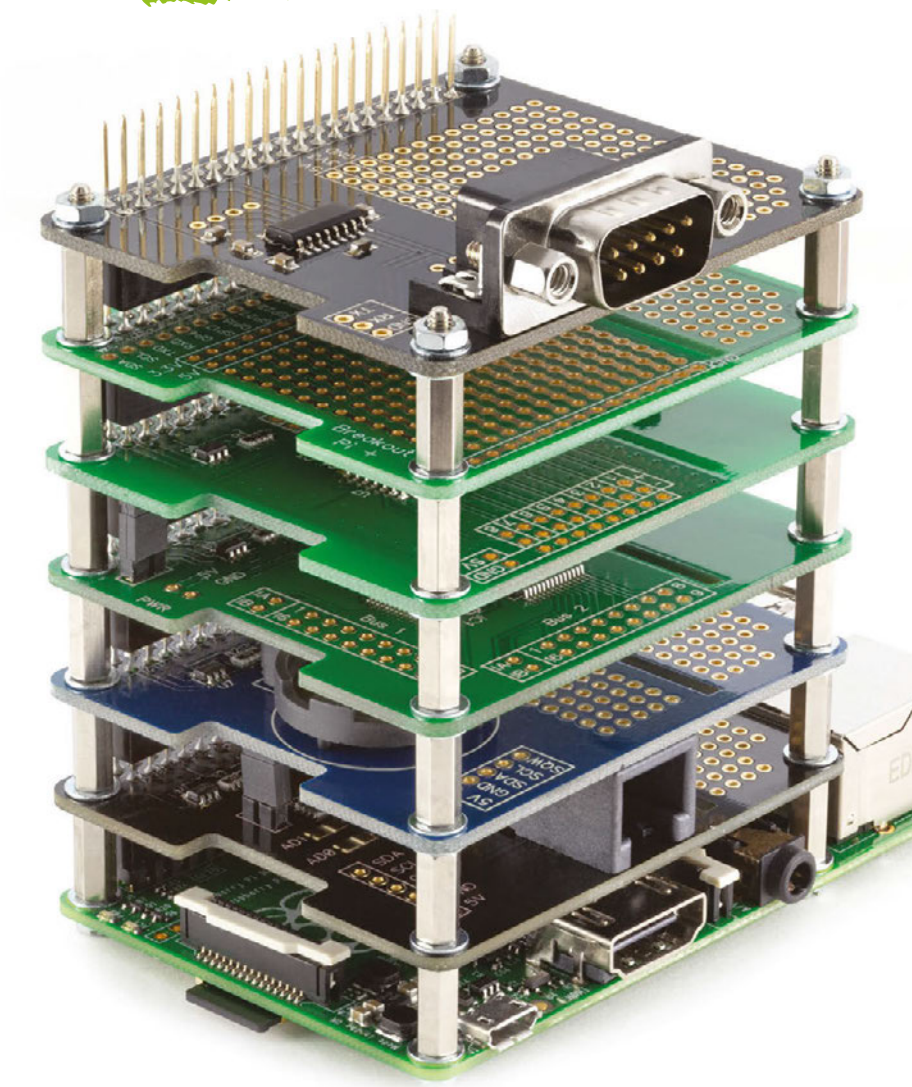

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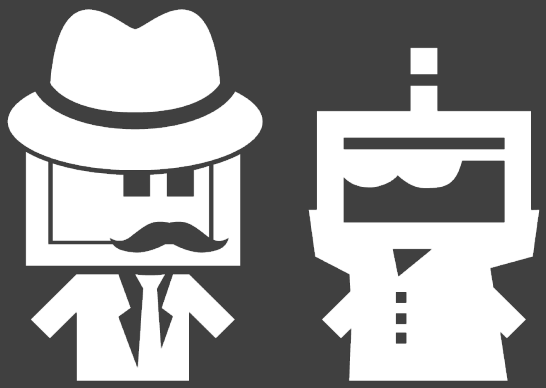

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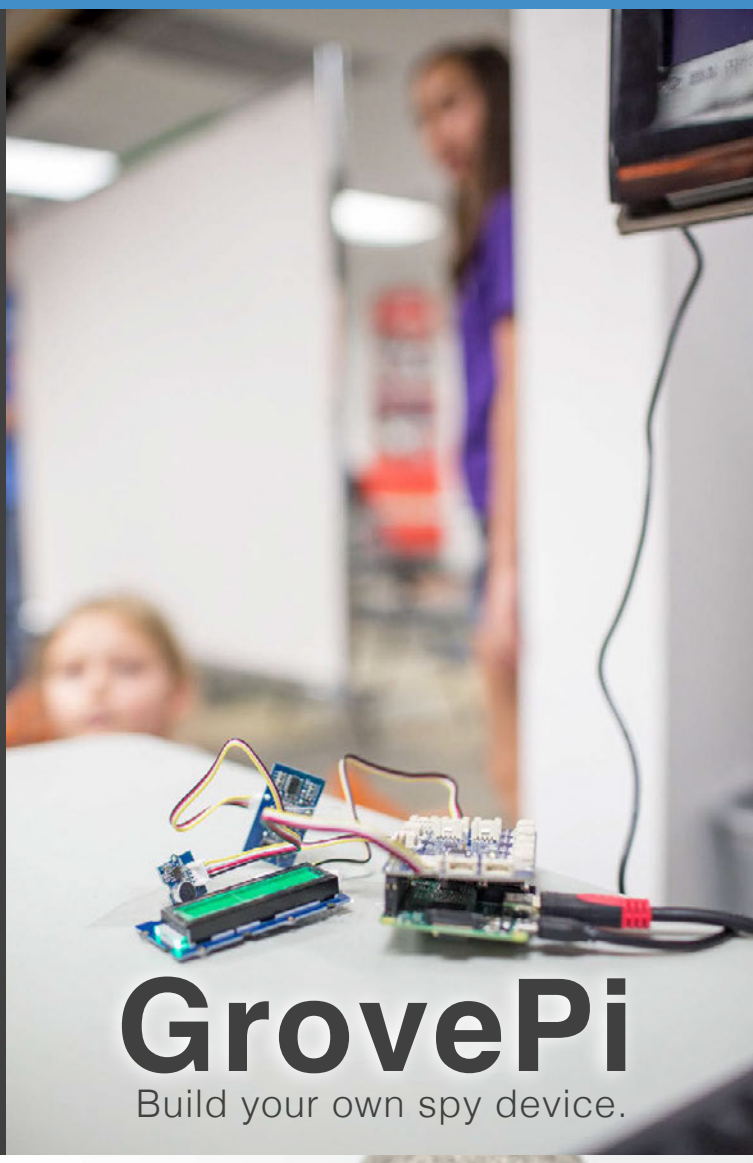

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